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Volume 1—Productivity

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LETTERS OF TRANSMITTAL

SEPTEMBER 28, 1976.

To the Members of the Joint Economic Committee:

Transmitted herewith is the first volume of the Joint Economic Committee study series entitled "U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns." This series of approximately 46 studies forms an important part of the Joint Economic Committee's 30th anniversary study series, which was undertaken to provide insight to the Members of Congress and to the public at large on the important subject of full employment and economic growth. The Employment Act of 1946, which established the Joint Economic Committee, requires that the Committee make reports and recommendations to the Congress on the subject of maximizing employment, production and purchasing power.

Volume 1 comprises two studies on the important subject of productivity. One is by Professor John W. Kendrick, and the second by Professor Edward F. Renshaw. The Committee is indebted to these authors for their fine contributions which we hope will serve to stimulate interest and discussion among economists, policymakers and the general public, and thereby to improvement in public policy formulation.

The views expressed are those of the authors and do not necessarily represent the views of the Committee Members or Committee staff.

Sincerely,

HUBERT H. HUMPHREY,
Chairman, Joint Economic Committee.

SEPTEMBER 24, 1976.

Hon. HUBERT H. HUMPHREY,
Chairman, Joint Economic Committee,
Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith are two studies entitled "Productivity Trends and Prospects" by Professor John W. Kendrick, and "Productivity" by Professor Eward F. Renshaw. These two studies comprise volume 1 of the Joint Economic Committee's study series "U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns." This series forms a substantial part of the Joint Economic Committee's 30th anniversary study series.

Both of these papers attempt to assess independently production trends over the next decade. Professor Kendrick concludes that the overall rate of productivity increase over the next decade will be above the 1.7 percent annual rate of 1966–1972. Professor Edward Renshaw, on the other hand, concludes that the rate of productivity increase will gradually decline to zero and perhaps even become negative before the turn of the century.

Professor Kendrick believes that the basic forces in the economy that condition productivity growth—the human factor and the legal and institutional framework of the economy—are more favorable than those prevailing during the preceding two decades of relatively strong productivity advance, 1946–66.

Professor Renshaw's negative assessment of future productivity growth is based on such factors as speed, scale and the efficiency of energy utilization. These basic dimensions of technological progress, which he considers significant restraint on further growth, may provide a more important set of reasons for the recent productivity slowdown than such well-publicized scapegoats as absenteeism, work stoppages, changes in labor force composition, pollution control expenditures and natural resource scarcity.

There is also some disagreement between Professors Kendrick and Renshaw on the subject of how to promote productivity increases. In general, Renshaw feels that our knowledge with regard to the effective promotion of productivity advance is rather meager, and does not provide sufficient basis for developing measures.

Kendrick cites a number of measures which could, in his view, enable the American economy to resume a growth rate of productivity equal to or greater than that of 1946–66 in the decade ahead. Among them are tax policies and other measures that would significantly increae the proportion of GNP devoted to fixed investment; and, a more systematic approach to public investment.

The Committee is indebted to Professors Kendrick and Renshaw for their work in developing these thought provoking papers for the Committee. Professor Kendrick is currently serving as a member of the George Washington University faculty and is Chief Economist at the Department of Commerce. Professor Renshaw is a member of the faculty at the State University of New York.

Doctor Robert D. Hamrin of the Committee staff is responsible for the planning and compilation of this study series with suggestions from other members of the staff.

The views expressed are those of the authors and do not necessarily represent the views of the Members of the Committee or the Committee staff.

Sincerely,

John R. Stark,
Executive Director,
Joint Economic Committee.

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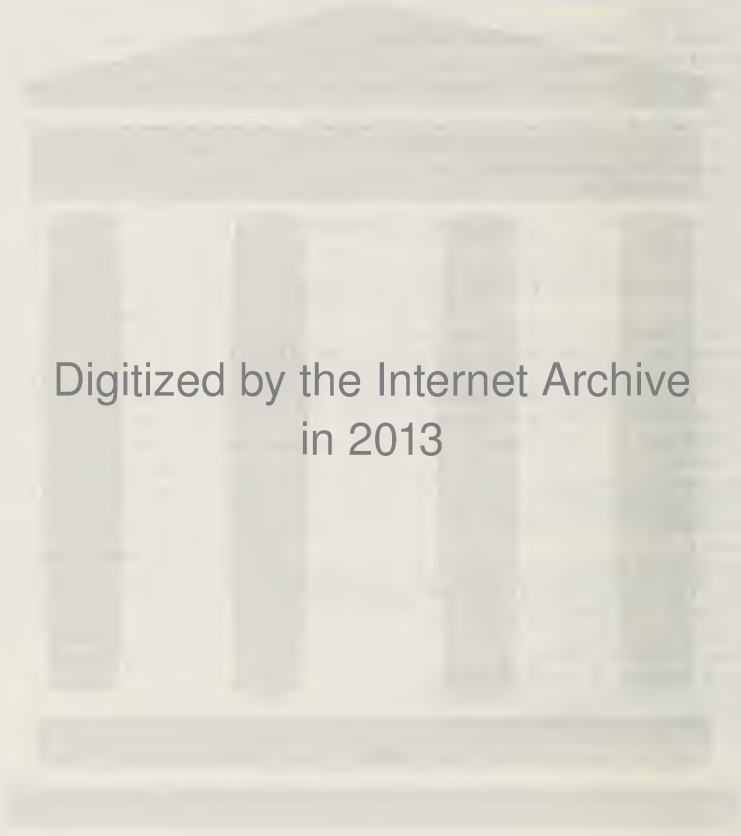

PRODUCTIVITY TRENDS AND PROSPECTS

By John W. Kendrick*

Introduction and Summary

For more than half a century, productivity advance has accounted for more than half of the growth in real gross national product in the United States. The rest was due to increases in inputs of resources—labor, manmade capital goods, and natural resources—when these are measured without adjustment for quality improvements. But since productive resource inputs have risen little, if any, faster than population, all of our increases in planes of living, defined as real income or product per capita, have been due to productivity advance. It is, therefore, of the utmost importance to pay special attention to the productivity factor in analyzing past economic growth and in assessing prospects for the future.

For the half century 1916–66, total factor productivity grew at an average annual rate of about 2.2 percent. Real product per hour grew at the rate of about 3.2 percent a year 1946–66, somewhat above the 1916–46 rate because of a faster growth of real capital per labor hour following World War II. The major forces promoting productivity are discussed in the text, and listed in table 3.

In the decade 1966–76, there was a distinct slowdown in rates of increase of both total factor productivity and real product per unit of labor input. The main reasons for the retardation are believed to have been: Changes in labor force mix, particularly the accelerated growth in proportions of youth and women; accelerating price-inflation; some deceleration in the rate of economic growth; a substantial decline in the ratio of research and development outlays to gross national product; negative social tendencies; and increased governmental intervention in the economy, including certain mandated social outlays and wage and price controls during the period 1971–74. Attempts have been made to quantify the productivity impact of some of these forces, as described in the text.

Looking ahead, I would expect the rate of increase of total factor productivity in the U.S. economy as a whole in the decade 1975–76 to 1985–86 to be somewhat above the 1.7 percent rate of 1966–73. In part, this would reflect the move from cyclically depressed rates of utilization of capacity currently to more efficient rates, assuming 1985–86 is a period of relatively high-level, or even average, activity.

More fundamentally, it reflects the lifting of some of the negative forces affecting productivity in recent years, particularly 1966–70, as reviewed below.

*Professor of economics (on leave), the George Washington University; currently chief economist for the U.S. Department of Commerce.

Note.—This paper was prepared before Dr. Kendrick joined the U.S. Department of Commerce in June, and it represents his personal views.

Abstracting from cyclical forces, however, I would expect that the trend-rate of total factor productivity advance in the next decade would be modestly below the 2.4 percent rate of the 1948–66 period. Basically, this would reflect a bit slower growth of R. & D.; slower productivity advances in extractive industries, and particularly in production of energy materials; and somewhat lesser opportunities for economies of scale as economic growth generally slows down somewhat as the growth of the labor force decelerates in the 1980's. There will be some offset to these negative factors as the proportion of investments and costs devoted to antipollution, health and safety, and energy conservation stabilize or possibly decline, and as a productivity payoff from these programs emerges.

The rate of increase in output per man-hour in the decade ahead may well equal the longer run trend-rate of somewhat better than 3 percent a year, on average. This more optimistic assessment of prospects for labor productivity relative to total factor productivity is based on the expected retardation of labor force growth in the years ahead. The U.S. Department of Labor projects a 1.2-percent average annual rate for 1980–85, compared with about 2 percent for 1966–73. Assuming that saving and investment propensities are maintained at their past levels, this means that capital per worker will grow significantly faster in the latter part of the decade ahead. Since the rate of increase in output per man-hour is positively correlated with real capital per man-hour, the growth of labor productivity should accelerate relative to the growth of total factor productivity. Thus, real income per worker may be expected to grow in line with past secular trends, assuming that average hours worked per year do not drop faster in the future than they have in the past.

Historical Trends

Table 1 shows the trends in productivity, defined both as real product per man-hour ("labor productivity") and per unit of total factor input (total tangible factor productivity). For these computations, both labor and nonhuman factor inputs are unadjusted for quality changes. Thus, changes in total factor productivity reflect changes in average quality of resource inputs, as well as changes in the technology and organization of production, changes in economic efficiency, and other factors spelled out in more detail in the next section. Changes in real product per man-hour additionally reflect changes in tangible nonhuman inputs per man-hour, appropriately weighted (the difference between rates of change in the two productivity ratios).

The rates of change are shown for subperiods between business cycle peak years 1948–73 and for the longer period 1948–66. It was tempting to show the rates of change for the entire three decades 1946–76, but 1976 was not a peak year and was affected by postwar readjustments, and even if estimates for 1976 were available, the year still reflects the 1973–75 recession. Note also that we show estimates for the private domestic economy (about 85 percent of the total), since productivity estimates for the public sector do not have sufficient coverage to be representative.

Over the quarter century as a whole, real business product grew at an average annual rate of 3.8 percent. Persons engaged increased by more than 1 percent a year, on average, but the gradual decline in average hours worked per year cut the rate of increase in man-hour back to 0.8 percent a year. Thus, real product per man-hour grew at an average annual rate of 3 percent a year. There was a slight saving in capital per unit of output, as the ratio of real product to capital rose at a 0.2-percent average annual rate.

When the man-hours, by industry, are weighted together with capital, based on shares of national income, total real factor input rose at a 1.6-percent average annual rate. Thus, total factor productivity is calculated to have risen 2.2 percent a year, on average. Since total factor input rose only slightly faster than population over the quarter century, total factor productivity accounted for all the rise of planes of living as measured by real GNP per capita.

The trend-rate of growth of total tangible factor productivity since World War II was closely in line with what it had been for the prior 30 years since World War I. At that time it had accelerated significantly from rates experienced in the 19th century and up until 1916 or so. There was a further acceleration in the rate of growth of real product per man-hour after World War II, however. For the three decades before 1948, real product per man-hour grew at a trend-rate of almost 2½ percent, after adjustment for the effect of the Great Depression, compared with better than 3 percent since 1948. The acceleration was due, of course, to a much faster increase in real capital per worker and per man-hour after 1948 than before, reflecting the absence of major economic contractions 1948–73 and thus a higher average rate of capital formation than previously. Specifically, the average annual rate of growth of real tangible capital stocks per man-hour accelerated from 0.6 percent 1919–48 to 2.9 percent 1948–73. When the difference of 2.3 percentage points is reduced by the 20 percent weight of capital, it is seen to account for the acceleration in labor productivity. The point is important, since the slower growth of labor force and man-hours worked projected in the 1980's may well permit a faster growth of the capital/labor ratio than experienced since the early 1960's (when labor growth began to accelerate), suggesting a renewed acceleration in labor productivity increase.

The lower part of the table shows rates of change in real product per man-hour for the major industry divisions of the business economy. The relatively wide dispersion of the 1948–73 rates is evident, ranging from little more than 1 percent a year in services up to almost 6 percent in the utilities. If finer industry detail were shown, the dispersion would be seen to be even wider. For example, within transportation, the local transit industry was one of few to show an actual decline in productivity over the quarter century; whereas for pipelines, the rate of gain was near 9 percent a year. The dispersion is also greater for shorter time spans than for longer.

Outside of the extractive industries and the service sector, there is a distinct positive correlation between rates of change in output and in productivity. To some extent, this may reflect differential opportunities for economies of scale. More important, those industries with above (below) average productivity gains have below (above) average unit cost and price increases, which generally affect sales and

output. In the case of farming and other extractive industry, however, both price and income elasticities of demand are low, so output has increased less than in the economy as a whole, despite relative price declines reflecting above-average productivity performance. In services, price elasticity of demand is low, but income elasticity high, so that output has increased despite relative price rises reflecting below average productivity performance. Thus, while employment in extractive industries fell relatively (and absolutely), it rose relatively in the services sector.

In the rest of the business economy, output rose enough more in industries with above average productivity advance to offset the labor saving effects. In other words, technological unemployment was not a general problem on an industry basis. This is not to say that technological changes do not cause temporary labor displacements. They do with respect to occupations and localities, and a few selected industry sectors, as noted above, requiring policies to promote mobility. To the extent that such displacements cannot be accommodated within firms through retraining and/or relocation, the obligation of the Federal Government to assist in promoting the required mobility is recognized in the Comprehensive Employment and Training Act of 1973. Successful pursuit of the objectives of The Employment Act of 1946 is a prerequisite, of course, to the availability of new job openings for those displaced by technological and other changes inherent in a dynamic, growing economy.

The paths of production and productivity growth are not smooth ones. Abstracting from cyclical fluctuations, even when rates of change in real product and productivity are measured between business cycle peak years, there are still pronounced variations from one subperiod to another, as shown in the table. It will also be noted that there is some degree of correlation between rates of change in production and in productivity. In the private domestic economy as a whole, the first postwar subperiod 1948–53, was one of strong economic growth and the rate of productivity advance was also above average. The next two subperiods between 1953 and 1960 saw much slower economic growth, as a result of policies adopted to slow inflation, and productivity advances were a bit below average. The subperiod 1960–66 saw the most rapid rate of economic growth of all. While productivity increase was well above average, it was not as high as between 1948 and 1953. In the subperiod between 1966 (which preceded the mini-recession of 1967) and 1969, the economic growth rate slowed somewhat to 3.4 percent a year, below the trend but well above the depressed rates of 1953–60. Yet productivity increases slipped sharply to 1.7 percent a year rate for output per man-hour and 1.1 percent for total factor productivity, well below the rates of 1953–60. In the 1969–73 subperiod, economic growth was approximately on trend, but productivity remained below the trend, and the rates of increases were slightly below average.

Much has been written about the productivity slowdown which began in 1966. Clearly, changes in rates of economic growth were only a small part of the picture, and other forces must be looked to for the major causes of retardation. After setting forth an analytical framework for investigating the major causes of productivity advance, we shall apply it in a discussion of causal forces during the 1948–73 period, with special reference to the slowdown after 1966. This is a necessary background for looking forward to the next decade, 1976–86.

Causal Forces Behind Productivity Advance

Over the longer run, the chief force behind productivity growth is technological progress, resulting from cost-reducing innovations in the ways and means of production. In the short-run, other factors are also significant.

Short-Term Factors

Changes in rates of utilization of capacity of individual plants, industries, and sectors away from or toward the most efficient rates obviously affect rates of productivity change. This is largely a cyclical phenomenon, but differences in average rates of utilization between successive business cycle peaks would also have some effect on subperiod rates of change. The effect on long-run trends would be minor.

Also in the short run, change in degree of efficiency of production relative to the potential efficiency with a given technology would affect productivity change. In the case of relatively new technologies, the steepness of the "learning curve," that is, the rapidity with which the requirements of a new technology are learned by individuals or groups, and integrated in organization routines, affects productivity. In this area, the rate of investment in training and retraining would be a factor. Even in the case of older technologies, the degree of labor efficiency, relative to realizable standards or "norms" affects productivity. Changes in efficiency, so defined, as revealed by "work measurement," should seem largely to depend on motivational factors, given the institutional framework. Labor efficiency, like utilization rates, seems to have a systematic cyclical component. That is, productivity rises before the trough, as the profit squeeze increases managements' cost consciousness, and as rising unemployment motivates workers to value their jobs more highly and work more productively. The reverse of these factors may help account for the slowdown of productivity gains before cycle peaks.

Finally, since innovations and their diffusion usually require investments, and investment is notoriously cyclical, so also is innovation. But the effect on productivity may be obscured by other factors. For example, while a decline in the rate of tangible investment will retard the growth in efficiency of the existing capital stock—as its average age increases—the tendency to concentrate production in newer, more efficient plants in a recession would help raise productivity. Similarly, the tendency toward upgrading the employed labor force in a contraction would obscure a retardation in growth of quality of the total labor force as human investment declined. The opposite, conflicting, tendencies would appear in an economic expansion.

Secular Forces

Productivity advance is not a magical touchstone that raises output more than inputs at no cost. Indeed, the technological advances that reduce unit real costs and raise productivity usually require investments to create the new knowledge and know-how, and to incorporate them in human beings and in nonhuman productive agents. There are other, noninvestment-related forces that affect productivity, which we shall enumerate after discussing the more important investment categories.

Investments

All outlays that contribute to output- and income-producing capacity—capital—for future periods may be defined broadly as investment. This definition includes not only the outlays for tangible structures, equipment, inventories, and development of natural resources, which are traditionally considered to represent capital formation. By analogy, it could also include the cost of rearing children to working age, i.e., the formation of tangible human capital. But more importantly, it is the intangible investments designed to improve the quality and efficiency of the tangible nonhuman and human factors which are of particular significance in explaining productivity advance.

The fountainhead of technological progress is basic research, which increases human knowledge. On the one hand, basic research feeds into, and draws from, applied research, development, and engineering designed to develop new products—including cost-reducing producers goods—and new processes. Thus, new technology becomes embodied in producers' goods and processes and is diffused through tangible investments in successive generations, "vintages," of capital goods. Note that as a carrier of technological progress, the rate of tangible investment is important. If the rate speeds up and the average age of durable capital declines, this contributes to an acceleration in the rate of productivity advance and vice versa.

On the other side, both basic and applied research feeds into, and draws from, education and training. The advances in knowledge and know-how increase the content and quality of curriculums. Increases in both the quantity—years of schooling—and quality of education and training per worker are necessary to enable the labor force to initiate and adapt to an increasingly complex technology. Likewise, investments in medical care, health, and safety enhance the quantity and quality of human inputs by prolonging working life, by reducing time lost due to illness and accident, and by increasing vitality as chronic and debilitating conditions are overcome.

Actually, it is the growth of the stocks of the intangible capital embodied in the work force and nonhuman tangible capital goods relative to the quantities of the latter, unadjusted for quality, that would be expected to increase productivity. Also, it is the advances in technological knowledge resulting from research and development which render economic the increasing intensities of tangible and intangible investments per worker and per man-hour by raising the prospective rates of return.

Other.—There are several forces which affect productivity that do not directly involve investments. First, there are internal and external economies of scale. There are the opportunities opened up by growth of markets for greater specialization of men, machines, and plants, and the spreading of overhead type functions over more units. Technological progress helps push out the frontiers of optimum scale, so that this force continues operative even after substantial growth. It should also be noted that potentialities for scale economies frequently require investments for realization. But it seems appropriate to list it as a separate force.

The second major factor is changes in the degree of economic efficiency—that is, allocation of resources in accord with the com-

munity's preferences. Perhaps the ideal model is that of the perfectly competitive economy, in which knowledge is complete so that changes are adjusted to instantaneously. Actually, monopolistic and restrictive practices by managements and labor unions, and market interventions by governments, create distortions in the allocation of resources. Thus, changes in institutional forces and practices affect productivity. Further, the market is not perfect so that the mix of investments and capital, and distribution of the labor force, are generally suboptimal. The problem is compounded by the frictions and lags in adjusting factor supplies to changes in relative demands due to changes in technology and other dynamic forces. Thus, more rapid adjustments to change could raise productivity. To some degree, this may involve investments in market research in the case of capital, and in physical mobility costs, in the case of labor.

Finally, there may be changes in the average inherent quality of natural and human resources [there is no inherent quality of man-made capital goods] not counting changes in quality due to investment. The tendency toward diminishing returns in extractive industries is an old law whose relevance has been recognized anew in recent years. In the case of labor, average quality may change as a result of changing mix of groups [particularly age brackets] with different productivities as reflected in earning capacities. Or, if one is looking at man-hour input, changes in the quality of an hour's work of a given type due to changes in the length of the workyear could be included under this rubric.

Explanations of Recent Productivity Trends

It is difficult to quantify the effects of the various causal forces on productivity change. Even if all the significant forces can be identified and measured, it is still hard to disentangle the effects of the several variables, since they interact. For example, technological advance resulting from research and development creates demand for more professional personnel and thus for educational investment. Despite the difficulties, a number of economists have tried to narrow the productivity residual by measuring the effects of some of the causal forces. All of the investigators are still left with a final residual, however, which reflects the net effect of all the factors not explicitly included in the explanatory schema.

In my own earlier work, I weighted man-hours and capital inputs by average compensation in terms of about 30 industry groupings. Relative shifts of resources toward industries with higher average pay and returns resulted in weighted factor inputs rising about 0.3 percentage points more than unweighted inputs [or about 15 percent of the residual].

Professor Dale Jorgenson has followed a more elaborate weighting scheme.[1] For labor, he measured input in terms not only of industries, but also of sex, race, occupational and educational classes. His weighted labor input rose by 0.8 percentage point more than unweighted, 1947–73, which he took as a measure of labor quality im-

[1] See Frank Gallup and Dale Jorgenson, "U.S. Total Factor Productivity by Industry, 1947-73"; and L. Christensen, D. Cummings, and D. Jorgensen, "An International Comparison of Growth in Productivity, 1947–73"—papers prepared for the Conference on New Developments in Productivity Measurement, Williamsburg, November 1975 (New York: National Bureau of Economic Research, mimeograph).

provement. His capital input index, weighted by average rental rates in 65 industry groupings, rose by 1.2 percentage points more than an unweighted measure. His total factor quality measure rose by about 1 percentage point, which explains over 40 percent of the difference between the 4.2 and 1.9 average annual percentage rates of increase in real product and unadjusted total factor input.

I obtained a similar result in a recent study for the National Bureau of Economic Research using an alternative approach. I estimated the real stock of capital resulting from investments designed to increase the efficiency, or quality of the factors of production. These comprised research and development, education and training, health and mobility. The total real stock of capital, human and nonhuman, including the intangible stocks associated with rising quality, grew by 0.8 percentage point a year more than the real unadjusted stock, 1948–69. Again, this represented somewhat over 40 percent of the productivity residual, that is, the difference between rates of growth of real product and real stocks of labor and capital unadjusted for quality. This computation assumes the same average rate of return on intangible investment as on tangible. There is some evidence that the rate of return on intangible investment has been higher, in which case the contribution of quality improvements associated with technological and organizational progress would be higher.

Perhaps the most painstaking and comprehensive effort to partition economic growth generally, and productivity increase in particular, among causal forces is that by Edward F. Denison.[2] His analysis of sources is shown in table 2, rearranged slightly for comparability with my approach. Denison includes changes in the quality of labor as part of labor input, so that his productivity estimate is correspondingly lower. In the table, I also show the quantity of labor input separately and a productivity variable relating real product to combined quantities of capital [including land] and labor, unadjusted for quality. The latter productivity variable shows an average annual rate of increase 1948–69 of 2.68 percent, compared with my estimate of 2.6 percent when inputs are not weighted by industry.

Denison estimates that the increase in labor quality accounts for 0.58 percentage point of the growth rate, or about 22 percent of the rate of productivity advance. Including labor quality with input, Denison's rate of productivity advance is 2.14. The increase in labor quality was due largely to the effects of increased education, as was true of Jorgenson's estimate. There was a 0.12 negative effect of shifts in age-sex composition, particularly in the latter sixties, towards groups with lower earnings. But this was offset by the positive effect of other intergroup shifts. There was a small positive effect in the efficiency of an average hour's work due to the downward trend in the average length of the workweek and workyear.

Also explaining almost 20 percent of the broader productivity change measure was economies of scale, in both local and national markets. This factor is, of course, related to the rate of economic growth itself. Over this period 1948–69 it was, however, partially offset by the effect of a decrease in the intensity of demand relative to capacity.

Improved resource allocation accounted for about 13 percent of the productivity gain. This was due chiefly to the continuing relative shift

[2] Edward F. Denison, Accounting for United States Economic Growth, 1929–69 (Washington: The Brookings Institution, 1974).

of resources out of farming, but also reflects the relative decline of nonfarm self-employment.

Finally, the residual, which Denison interprets as reflecting advances in knowledge predominantly, comprises slightly more than half of the rate of productivity increase. Since Denison does not separately measure improvements in the quality of capital, his residual reflects the advances in knowledge embodied in plants, equipment, and developed land. It also reflects the improved quality of education and training as advances in knowledge improve the corpus transmitted, although Denison's labor quality captures increases in the average amount of education per worker. Presumably, most of the advances in knowledge in the modern era stem from investments in R. & D. although scientific advances and inventions may still come from informal activities.

The Productivity Slowdown After 1965

The productivity slowdown in the latter 1960's led to a number of attempts to explain the reasons for the retardation. This exercise, like the one we just went through to decompose the secular trend rate, is a useful background for evaluating future developments.

Denison applied his approach to the subperiod 1964–69, which showed a retardation of 0.53 percentage point in productivity advance relative to trend. His numbers indicate that almost one-third of the slowdown was due to changes in the age-sex composition of persons engaged. The bulge in labor force growth in the latter 1960's increased the proportion of youth. Also, the increase in the proportion of women accelerated. Since both groups receive below-average compensation, this relative growth was a factor retarding productivity advance as measured. The rest of the productivity slowdown, according to Denison's figures, was the result of a decline in the intensity of demand relative to capacity. Denison's other forces contributed as much or more to growth 1964–69 as over the longer period since 1948. In particular, advances in knowledge showed much the same rate of increase at the end of the period as throughout.

George Perry, looking at a slightly different period, 1965–70, with respect to the deceleration in real product per man-hour, came to somewhat different conclusions from Denison (in Brookings Economic Papers, 1971). He found that 28 percent of the shortfall was due to the accelerated changes in the labor force mix with regard to youths and women, which is in line with the other estimates. He estimated that 36 percent of the shortfall was due to a decline in the rate of utilization of capacity, considerably less than the Denison estimate. Perry estimated that the gap between actual and potential GNP, which was 0.6 percent in 1965 and −1.7 percent in 1966, rose to 0.9 percent in 1969 and 5.8 percent in the recession year 1970.

Thus, the Perry approach indicates that other factors must have been involved in the productivity slowdown. He does not attempt to assess these, but the present writer has suggested a number of additional forces he considers important.[3] First, as is well known, after rapid increases for several decades, research and development outlays

[3] See John W. Kendrick, "The Productivity Showdown." *Business Economics*, September 1971.

peaked out as a ratio to GNP at 2.9 percent in 1964, declining to 2.91 percent in 1966, 2.75 percent in 1969, and 2.33 percent in 1973, and in 1975. As a result, the real stock resulting from research and development investments decelerated from a 9.3-percent average annual rate 1948–66 to 6.5 percent 1966–69 to 4.3 percent 1969–73. The deceleration of the ratio of research and development stock to the tangible capital stock was even greater. The impact of this deciine was mitigated by the fact that much of it came in the military area. Further, since the diffusion of new technology is slow, the full impact of a slower rate of increase in the cost-saving characteristics of new technology takes time to affect average rates of change.

The accelerating inflation beginning in 1966 may well have diverted resources from productive uses, tending to slow productivity. More importantly, it eroded the real profit rate. Nevertheless, business managed to increase capital per man-hour—but not per worker—at past rates, although at the expense of expanding debt relative to equity. This is all the more remarkable in view of substantial increases in national security outlays financed in part by increased tax rates.

Finally, the negative social trends in the latter 1960's—increased drug abuse, crime, antiestablishment sentiment—associated with the Vietnam war, must have had some unfavorable impact on productivity advance, although social indicators are not well developed enough to permit quantification of these tendencies and their effect. The impact would fall primarily on the social and legal framework of the economy, and on labor efficiency itself.

The factors explaining the 1966–69 slowdown also help to explain why productivity advance recovered almost back to the trend-rate during the final complete subperiod, 1969–73. In the first place, there was no further sagging of actual output in relation to potential between 1969 and 1973. Some capacity utilization numbers suggest that the average rate of utilization was slightly higher in 1973. Certainly, rates were abnormally high in some of the basic industries in which investments apparently had been inadequate in the prior years. Second, the slowdown in the increase in average quality of the labor force due to changes in mix was largely over, and the rate of increase was almost back to trend 1969–73. According to the estimates by Jorgenson and Gallop, the increase in their labor quality index, which averaged 0.7 percent a year 1947–66, slowed to under 0.3 percent 1966–69, recovering to 0.6 percent 1969–73. Finally, opportunities for economies of scale increased somewhat 1969–73 as the rate of economic growth rose to 3.8 percent a year compared with 3.4 percent 1966–69. The rate of increase in the real stock of know-how resulting from research and development in relation to real tangible capital—business sector—stocks, which had dropped from 6.6 percent a year 1948–66 to 2.3 percent 1966–69, dropped further to 0.6 percent 1969–73. But it will be noted that the rate of deceleration was significantly less in 1969–73 than in the previous subperiod.

The various forms of human capital—education, training, health and safety—continued to rise at approximately their trend-rates up through 1973, according to my most recent estimates.[4] This contributed to the resumption of the favorable shifts in labor-force mix.

[4] "Economic Growth and Total Capital Formation," study prepared for the Subcommittee on Economic Growth of the Joint Economic Committee, Congress of the United States (Washington: GPO, Feb. 18, 1976).

With respect to economic efficiency in allocating nonlabor resources, capital continued to flow towards the areas with higher rates of return. But allocations were undoubtably distorted somewhat by the episode of wage and price controls, 1971–74, which are blamed in part for the capacity shortages that developed in key industries during that period. They were undoubtedly aggravated by the reduced real rates of return on investment in 1973 relative to 1966 as a result of the accelerating inflation and the restricted macroeconomic policies invoked to deal with it.

With regard to basic values and attitudes, as U.S. involvement in Vietnam was gradually phased out between 1969 and 1973 there was a gradual healing of divisiveness and reduction in antiestablishment sentiment. Although many youths had questioned the materialistic aspects of our society, most became integrated in the work-a-day world just as previous generations of youth have been. Although many questioned the goal of economic growth, the actions of most Americans indicate that they still desire higher real incomes for themselves and their children, although they have become more concerned about the qualitative aspects of growth, supporting measures to protect the environment.

The social concerns led to legislation which had some impact on productivity—particularly the acts creating the Environment Protection Administration and the Occupational Health and Safety Administration. The rapidly increasing outlays in these areas in the early 1970's which increased costs and inputs but not outputs as measured, has a small negative impact on productivity advance.

In short, whereas some of the negative forces which had depressed productivity advance 1966–69 were no longer operating, or operating less strongly 1969–73, the net effect of other factors was slightly on the negative side, preventing a complete recovery to the secular trend-rate of advance.

Prospects for the Decade Ahead

In looking ahead, it is important to realize the strength and persistence of the upward productivity trend in the United States. On a total factor basis, it has averaged around 2¼ percent a year for about 60 years. One reason for the relatively good record of long-term projections of real GNP has been the reasonably steady growth of productivity. It is true that there have been periods of acceleration and retardation in productivity advance, as is true of most economic time-series. Notably, there was the marked slowdown of the latter 1960's, which led some to fear a permanent deceleration. But most of the depressing factors appear to have been temporary with the possible exception of the reduced growth of the research and development stock, and even that was due mainly to the cutback of publicly financed and largely defense-space related activity. Certainly, the virtual recovery of the productivity rate 1969–73 puts the burden of proof on those who expect the deceleration to continue.

My own appraisal is that the rate of productivity advance is more likely than not to accelerate over the next decade compared with the past decade, particularly when it is measured in terms of output per man-hour. This view is based on more than mechanical extrapolation

of the long swing, in which periods of slow growth in real product and productivity are invariably followed by periods of above-average advance. It is based in part on the deeper view that there are cybernetic forces in the economy and in the broader society which lead to the correction of unfavorable tendencies either through built-in stabilizers, or as a result of conscious policies to reverse the negative trends once they are recognized as such.

In this final section, the analytical framework developed earlier is used to evaluate qualitatively the direction of the effect of the significant variables on the rate of productivity advance relative to the trend rate since 1946, and relative to the somewhat lower rate of the past decade. (See table 3.) It would be more elegant if we could construct a model with precise coefficients to indicate the productivity impacts of projected changes in the significant independent variables. But the productivity variable is so complex, reflecting the net effect of myriad economic, social, and natural phenomena, that no credible econometric model has yet been constructed. Even if it could be, the projections of the independent variables would be far more crucial than the system of equations embodied in the model. And, of course, the coefficients based on past relationships might well change over a forecast period of as long as a decade. The effort here is more modest—to bring judgment to bear on the probable course of the major causal factors relative to past trends, and then attempt to weigh the net impact.

Looking first at basic forces, I believe that the basic values and attitudes still favor economic progress in the United States. The "hippie" culture never really took hold of significant population groups, and most Americans still appear to desire increasing real income for themselves and their children, judging from their actions as individuals and as members of organizations such as trade unions. True, as average education rises, people are more concerned with the quality of work and working life, but if increased job satisfaction is realized this should promote productivity. Further, the efforts of women and various minority groups to attain income parity should also increase incentives for higher productivity. The ending of the involvement in Vietnam in 1973 reduced the appeal of various radical groups and increased the willingness of social critics to work within the system to achieve desirable social change.

Although criticism of the business economy undoubtedly mounted during the past decade, there does not appear to be widespread sentiment to alter radically our predominately private enterprise, market-directed economy, with its rewards for superior performance and penalties for inefficiency. Many reports of foreign productivity teams that visited the United States after World War II emphasized the view that our competitive market system was "the secret of American prosperity." Some of the socialist systems are experimenting with greater reliance on the price mechanism as a means of spurring managers to devise and adopt cost-reducing innovations. In our own system, even in the regulated industries, there is a trend toward reducing the regulated areas, and elsewhere to develop regulatory techniques which encourage and reward superior productivity performance.

Even in the areas in which governmental intervention has increased, such as environmental protection and occupational safety, there is

pressure to develop more reasonable standards with an eye to the cost-benefit relations and trade offs with other objectives such as productivity advance and energy conservation and development.

An institutional innovation which was small but significant was the creation in July 1970 of what is now called the National Center for Productivity and the Quality of Working Life. This was a response to the productivity slowdown of the latter 1960's, and illustrates the cybernetic mechanism referred to earlier. In addition to encouraging productivity measurement, analysis, and promotion in the private and public sectors, the Center is in a position to assess the productivity impacts of existing and proposed governmental programs, and thus aid in developing policies to accelerate productivity advance.

On balance, it is my impression that the basic forces in the economy that condition productivity growth—human values and the legal and institutional framework of the economy—are more favorable than those prevailing during the preceding two decades of relatively strong productivity advance, 1946–66. They may even become more favorable, but such a prediction would be very speculative.

Of the proximate determinations of productivity increase, several appear to be more favorable for the next decade than for the last. One is the predominantly short-run factor of rates of utilization of capacity. In the last quarter of 1975, the Commerce Department estimate of the manufacturing capacity utilization rate was 79, compared with 85 for 1969 and 86 for 1973. The FRB series showed 71 compared with 86½ for 1969 and 83 for 1973. So, if relatively full employment is assumed for 1985–86, it is clear that the decadal productivity growth rate from 1975–76 will receive a boost from the movement toward more efficient rates of utilization of capacity. Likewise, opportunities for economies of scale will be greater from 1975–76 to 1985–86—although the basic growth trend of real GNP, projected by BLS at 3.6 percent 1973–85 will be the same as from 1966–73, and a bit below the 1948–66 rate of around 4 percent per annum.

If I am right that values and attitudes have improved since the end of the Vietnam conflict, then labor efficiency may well be higher relative to norms in the decade ahead than in the 1966–73 period, and more in line with performance in the prior two decades. Unfortunately, aggregate measures are not available in this area. Also, possible improvements in health and safety of workers, due to OSHA and EPA requirements and accelerated investments in these areas, should tend to raise productivity in coming years.

We come now to the factor associated with the rate of capital formation. With respect to research and development, the National Science Foundation projects that its ratio to GNP will stabilize at around the level of 2.2 percent for the next decade. This means that the stock of intangible capital resulting from research and development will increase at a rate similar to that of recent years, but at a lower rate than during the previous decades when research and development was rising in relation to GNP. The possible impact on productivity advance will be mitigated by two factors: (*a*) The decline in R. & D. outlays was concentrated in federally funded, defense- and space-related activities, which have relatively little impact on productivity; and (*b*) with a slower growth of R. & D. outlays relative to the period prior to 1966, the projects undertaken may well have a

higher average rate of return and productivity effect. Nevertheless the lower R. & D./GNP ratio is not a favorable factor.

Education and training outlays, and the growth of embodied intangible capital per worker, are expected to increase during the next decade at the rates experienced in the past several decades, according to HEW projections. Also, the relative shift of students away from science, engineering, and business administration in the late 1960's and early 1970's appears to have been reversed.

As noted earlier, the growth of intangible stocks per worker resulting from health and safety outlays was one variable that accelerated in 1966–76 relative to earlier years, due in part to OSHA requirements. It is expected that the growth will continue at near the recent rates, and above the earlier rates, in the coming decade.

Tangible capital formation, of particular importance as a carrier of technological progress, has proceeded at a fairly steady trend-rate ever since World War II. It has been slow in recovering from the 1973–75 contraction. But if after-tax rates of return are restored to a normal range, the rate of increase in the real stocks should approximate past trends. As noted earlier, the significant increase in the proportion of real investment devoted to antipollution, occupational health and safety, and energy-conservation purposes contributed to the productivity slowdown since the outputs of these programs are not included in the productivity measures, while the inputs are. But as the proportions of new investments devoted to these purposes level out and possibly decline over the next decade, the negative effect will be lifted. Also, as the required investments shift from a patch-up basis to a basis in which they are designed for integration with new plant and equipment, positive productivity results emerge.[5]

Coming to noninvestment forces, economies of scale were discussed earlier. With regard to economic, allocative efficiency, there has been little change in the degrees of concentration and unionization of American industry, nor does much change seem likely in the next decade. The degree of Government intervention did increase beginning in the 1930's, culminating in the wage and price controls of 1971–74 which resulted in relative price distortions with effects on resource allocation. Elimination of direct controls and the tendency toward less Government intervention should result in greater economic efficiency in the decade ahead than in the past decade. But otherwise it seems unlikely that there will be much change in the efficiency of the market-pricing mechanism as a means of allocating resources.

Connected with allocation is the effect of the changing mix of product by industry on productivity. With respect to total factor productivity, the chief effect of changing mix relates to the weights assigned differential industry rates of productivity change. Outside of farming and the service industries, there is a tendency for output to rise more in industries where productivity is rising at above-average rates, and where relative unit costs and prices are falling. But in agriculture, low-income elasticity of demand and above-average-productivity advance have caused resources to shift out, while in services, high-income elasticity and below-average-productivity advance have caused resources to shift in. The latter tendencies have

[5] See J. Myers, L. Nakamura, and N. Madrid, "The Impact of OPEC, FEA, EPA, and OSHA on Productivity and Growth," *The Conference Board Record*, Vol. XIII, No. 4, April 1976.

dampened national productivity advance. The trends are expected to continue. But if the relative shift out of extractive industry and into services is no faster than in the past, it will have no net effect on productivity advance. The BLS projections suggest that the shift may accelerate slightly in the next decade, but the acceleration is so minor, and so uncertain, that we would predict no significant effect on the productivity trend.

The average quality of natural resources is undoubtedly declining, with a consequent tendency toward diminishing returns. Up until recent years, this tendency was more than offset by technological advance. But since 1966, the rate of increase of productivity in mineral industries has decelerated. It also appears that it may have decelerated mildly in agriculture since 1969. If the programs designed to achieve greater relative energy independence in the decade ahead go forward, there may be an even greater negative impact on productivity than would be the case if imports of fuels were admitted freely. But the total effect should be relatively small in view of the modest share of total costs accounted for by raw materials generally, and energy materials in particular.

Concluding Comments

The conclusions regarding future productivity trends were summarized in the first section of the paper. Briefly, it appears that productivity advance during the decade 1976–86 will be stronger than it was during the past decade, reflecting cyclical factors and the mitigation of the negative effect of most of the factors depressing productivity growth after 1966. However, advances in total factor productivity in the coming decade may not be quite large as they were in the first two postwar decades 1946–66. The two chief reasons for a slightly lower trend-rate are the lower proportion of GNP expected to be devoted to research and development activities, and the declining quality of domestic natural resources in conjunction with programs for greater energy independence.

The foregoing review of the various forces that will affect productivity in the years ahead makes plain the enormous complexity of the problem, the difficulties of projection, and the large margins of error that must surround a projection. The saving grace is the tendency for errors in the projections of individual factors to offset each other, and the persistence of underlying trends in aggregates.

It must be noted that the discussion of productivity prospects has been predicated on the continuation of present and prospective institutional forms, practices, and policies short of the adoption of major programs designed to accelerate productivity advance. The latter are certainly not out of the question, however, in view of the wide publicity given to the productivity slowdown, and mounting public and official concern. In this concluding section, we shall present an overview of the sorts of policies that could result in the American economy resuming a growth rate of productivity equal to that of 1946–66, or possibly somewhat above it, in the decade ahead.

A primary approach would be the adoption of tax policies and other measures that would significantly increase the proportion of GNP devoted to fixed investment, which would accelerate the rate of growth

of real stocks of structures and equipment. Various studies in recent years have pointed to the large volume of capital that will be required to accommodate the growth of real GNP at relatively full employment levels, to effectuate cost-reducing innovations, to implement the mandated antipollution and OSHA programs, and to achieve greater energy independence. A study by BEA, cited in the 1976 Annual Report of the Council of Economic Advisers, for example, estimates that the proportion of GNP devoted to gross private fixed investment 1976–80 would have to rise by about 2 percentage points over the average of recent years in order to meet the projected requirements.

An increased proportion of GNP devoted to fixed investment would result in a decline in the average age of plants and equipment. Since newer vintages of fixed capital embody more recent technology, a decline in average age is associated with a faster rate of productivity advance.

Given the key role of profits as an investment determinant, it will be important in coming years for macroeconomic policies to permit the restoration and maintenance of adequate profit rates. It is likewise important that business confidence in the prospects for reasonably strong and steady growth of markets also be restored and maintained. Over and beyond the basic elements, more immediate measures could be taken to increase after-tax profits and cash flow by reducing the effective rate of corporate income taxes. The administration has made several proposals to this effect that have not yet been legislated: (1) A reduction in the corporate income tax rate from 48 percent to 46 percent; (2) gradual integration of the corporate and personal income taxes to eliminate the double taxation of dividends, with half of the benefit accruing to corporations and half to individual dividend recipients; (3) allowance of accelerated depreciation for tax purposes by firms in high-unemployment areas.

In 1975, the investment tax credit was raised from 7 percent to 10 percent. A Senate bill would make the credit permanent. It would, of course, be possible to increase the credit further, or an additional credit might be applied to increases in investment over that of a base period. Another possibility would be to allow inflation accounting for tax purposes, particularly revaluation of depreciation charges to replacement cost. Although inflation accounting, according to concrete guidelines, would result in some immediate reduction in effective tax rates, more importantly it would protect businesses against a renewed acceleration of inflation which in the past has tended to squeeze profits.

Further study is needed of the relative effectiveness of these and other alternative methods of increasing after-tax profit rates, and to appraise the degree of stimulus needed to meet the capital requirements of coming years, including investments designed to reduce costs. But adoption of some or all of the measures noted above could result in a faster rate of productivity advance.

A more systematic approach to public investments, both those that enhance private sector productivity and those that reduce costs of government, would also be favorable to productivity increase. For both types of investment, proposed projects should be evaluated with reference to the expected rate of return in relation to the appropriate discount rate, as is done in private industry, except that governments must consider the broader social rate of return. Projects whose present

value exceed their cost should be initiated, instead of being subject, along with current outlays, to vicissitudes of the budget process. This objective might be furthered by "capital budgeting" by governmental units. Investment projects which were economic could be funded by borrowing (or from budget surpluses) with interest and amortization charged to the current budget. By this procedure, worthy projects would not become casualties of periodic economy drives. Such drives represent false economy, of course, when they eliminate capital outlays that would pay for themselves, including interest on borrowed capital.

With respect to intangible investments, probably the largest potential productivity impact would come from measures to accelerate the growth of R. & D. outlays. It will be recalled that our projection assumes a stabilization of R. & D. at about 2.2 percent of GNP. This contrasts with the relative growth of these outlays prior to the mid-1960's, when they began growing less rapidly than GNP. Private business outlays for R. & D. could be stimulated by expanding the coverage of the investment tax credit to include R. & D. Alternatively, the stimulus could be obtained at less cost to the Treasury by allowing a somewhat larger tax credit for incremental R. & D. over that of the previous year or some other base period. Elsewhere, I have also suggested that the tax credit for R. & D. outlays by manufacturers of producers' goods should be larger than standard, in view of their greater impact on productivity advance.[6]

On a broader plane, the Federal Government needs to develop a more comprehensive and rational policy to promote science and technology than has existed hitherto. The reestablishment in mid-1976 of the Office of Science Adviser to the President, after a lapse of several years, is an encouraging development. In particular, a consistent policy of increasing Federal funding and performance of R. & D. in areas in which private activity is insufficient is central to the governmental role. The sharp reduction of Federal funds for R. & D. beginning in 1969, which led to increased unemployment of scientists and engineers because no provision was made for phasing in new public or private programs, reflects the lack of policy planning that must be corrected in the future. The importance of R. & D. cannot be overemphasized, since invention and development to the commercial stage of new products and processes tends to raise the expected rate of return on tangible capital outlays, and thus stimulates the new investments that embody new technology.

The other types of intangible investment—education and training, health, safety, and mobility—do not appear to require special stimulus at this time. But, these areas, as well as R. & D. and tangible investment, should be monitored on a continuing basis to insure that the total investment mix is optimal.

This leads to consideration of possible innovations in the institutional framework of the economy to promote productivity. I believe there could be a significant productivity impact from creation of a Federal agency with a primary responsibility for monitoring economic growth and progress, and developing recommendations for basic

[6] See John W. Kendrick, "Productivity Issues, in *Trade, Inflation and Ethics, Volume V* of Critical Choices for Americans series (Lexington : Lexington Books, D.C. Heath and Co., 1976).

policy and specific legislative and administrative measures to promote economic progress generally, and productivity advance in particular. The agency would serve as a focal point for all the activities related to longrun economic development in the Federal Government. It would review existing and proposed programs from the viewpoint of their productivity impacts, and develop recommendations of its own for the President with respect to desirable administrative initiatives or new legislative proposals. The agency would also maintain liaison with State and local governments, and private groups such as trade associations and labor unions, to receive and disseminate productivity-promoting ideas.

The Council of Economic Advisers does concern itself to some extent with long-run trends, but its major focus is necessarily on current developments and the measures required to attain the objectives of the act in a cyclical context. The Employment Act of 1946 could, of course, be amended to expand the functions of the council and the Joint Economic Committee of Congress to comprehend the promotion of productivity and economic progress. Or, a new agency could be created. In either case, funding should be sufficient to permit the agency to do a thorough job on an ongoing basis.

The National Center for Productivity and Quality of Working Life, as presently constituted, is not able to carry out the broad developmental function described above. It is governed by a multipartite Board of Directors, so that its policy statements tend to represent only those measures on which broad agreement can be reached by representatives of business, labor unions, various governmental agencies, and the public. In practice, much of its effort—limited to date by small appropriations—has been directed toward promoting labor-management cooperation to raise labor productivity. Admirable though that objective is, it is only one part of the much broader mission envisaged above. Promotion of total productivity and economic progress involves promoting natural resources development and capital formation and the efficiency with which natural resources and manmade capital, as well as labor, are used. It involves promotion of science and technology, and the coordination of the many activities of Federal Government departments and agencies that impinge on productivity and economic progress. The National Center might be restructured to perform the broader functions outlined above, with the Board of Directors converted to an advisory role. Or, if the Council of Economic Advisers or another independent agency in the executive branch were given the mandate to serve as the focal point for policies to promote economic progress, the National Center could continue to serve in a useful supporting role.

The point is that creation of a permanent agency with the central mission of monitoring longrun economic growth and coordinating and developing policies and measures to promote healthy economic progress should be able to make an impact on the rate of productivity advance. That is why I include the creation of such an agency as one of the measures—leading to a series of further initiatives—by which the U.S. economy could return to the 1946–66 trend-rate of productivity advance, or possibly exceed it, in the years ahead.

TABLE 1.—PRODUCTIVITY TRENDS IN THE U.S. PRIVATE DOMESTIC ECONOMY

[By major industry divisions; average annual percentage rates of change, 1948–73, by subperiods]

	Period						
	1948–66	1948–53	1953–57	1957–60	1960–66	1966–69	1969–73 [1]
Private domestic economy:							
Real product	4.0	4.6	2.5	2.7	5.2	3.4	3.8
Total factor productivity	2.5	2.7	1.9	2.2	2.8	1.1	2.1
Real product per unit of capital	.4	.2	−1.1	.2	1.7	−.9	.2
Real product per man-hour	3.4	4.1	2.7	2.6	3.6	1.7	2.9
Industry divisions (real product per man-hour):							
Agriculture	5.6	6.4	4.1	5.9	5.8	6.7	5.3
Mining	4.6	5.2	3.3	4.7	3.7	1.8	.2
Contract construction	2.0	4.4	3.2	1.5	−.5	−0	−.5
Manufacturing	2.9	3.7	2.2	2.2	3.6	2.7	4.5
Durable goods	2.8	3.6	1.4	1.8	3.8	2.2	
Nondurable goods	3.2	3.5	3.4	2.9	3.4	3.4	
Transportation	3.7	2.2	3.1	3.0	4.8	2.2	4.5
Communications	5.5	5.4	3.6	7.6	5.7	4.6	4.1
Electric and gas utilities	6.1	7.6	6.3	5.4	5.1	4.4	1.0
Trade	2.9	2.5	2.7	1.9	3.9	2.1	2.3
Wholesale	3.1	2.2	3.3	2.9	3.7	3.0	
Retail	2.7	2.6	2.2	1.2	3.8	1.0	
Finance, insurance and real estate	2.1	1.5	2.7	1.5	2.6	−.4	.2
Services	1.2	.5	1.2	1.1	1.7	.4	1.0

[1] Preliminary.

Note: Subperiods are measured between successive business cycle peaks.

Source: John W. Kendrick, "Postwar Productivity Trends in the United States" (New York: National Bureau of Economic Research, 1973); estimates extended from 1969 through 1973 by the author.

TABLE 2.—COMPONENTS OF ECONOMIC GROWTH (DENISON) [1] U.S. NONRESIDENTIAL BUSINESS ECONOMY

[Percentage points]

	1948–64	1964–69
Real sector income	3.72	4.52
Labor input, quantity	.46	1.84
Employment	.84	2.13
Average hours worked	−.38	−.29
Labor input, quality	.54	.36
Efficiency per hour	.05	.12
Intergroup shifts	.11	.13
Age-sex composition	−.12	−.38
Education	.50	.49
Capital inputs, quantity	.58	.78
Output per unit of input:		
Excluding labor quality changes	2.68	2.15
Including labor quality changes	2.14	1.79
Advances in knowledge and n.e.c.	1.44	1.43
Improved resource allocation	.37	.42
Economies of scale	.51	6.8
Irregular factors (esp. demand intensity)	−.18	−.74

[1] Adapted from Edward F. Denison, "Accounting for United States Economic Growth, 1929–69" (Washington: The Brookings Institution, 1974), tables 8–2 and 8–5.

TABLE 3.—FACTORS AFFECTING PRODUCTIVITY GROWTH, QUALITATIVE APPRAISAL OF EXPECTED INFLUENCE 1976–86

[0=neutral relative to influence in earlier period; +=positive; −=negative influence]

	Decade 1976–86 relative to period	
	1946–66	1966–76
Basic determinants:		
Values, attitudes	0	+
Institutional forms and practices	0	+
Proximate determinants:		
Short-run:		
Capacity utilization rates	0	+
Labor efficiency/standard	0	+
Long-run:		
Tangible investments	0	−
Intangible investments:		
Research and development	−	0
Education and training	0	0
Health, safety, etc	+	0
Economies of scale	0	+
Natural resources quality	−	−
Economic efficiency	0	+

PRODUCTIVITY

By Edward F. Renshaw*

Summary

In this paper we will first consider productivity from the perspective of such important dimensions of economic and technological progress as speed, scale, and the efficiency of converting energy into useful effects. We will then examine the recent productivity slump and the prospects for further improvements in productivity from the perspective of new technology and such basic economic inputs as labor, capital, energy, agricultural land, and pollution control expenditures.

The average annual growth rate for output per hour in the private domestic economy slumped from 4.1 percent from 1947–53 to only 2.1 percent from 1966–73. The prospects for further improvements in labor productivity, moreover, appear to be quite limited. My own guess would be that real GNP per worker in the United States will never again increase by more than about 30 percent and that most of the remaining increase will occur in the next two decades. Once our exisiting and yet to be discovered reserves of naturally occurring oil and gas are largely exhausted it may be very difficult for the United States to preserve an affluent way of life.

Most of the more industrialized nations of the world are now more than 90 percent dependent for their energy on fossil fuels and uranium. The prices and cost of these fuels can reasonably be expected to appreciate in real terms by from 10 to 100 fold or more in the next 1,000 years. It should also be noted that productivity in the U.S. oil and gas industry has been kept at a high level in recent years by drawing down fuel reserves which were discovered in the more distant past. This cannot go on forever. As we seek to be more self-sufficient in basic energy, productivity in the oil and gas industry, and in many other energy-dependent industries must necessarily decline or at least improve at a slower rate.

Productivity until fairly recently has been almost synonomous with improvements in output per man-hour. As we near the limits of technological progress, however, it will not be possible to increase one kind of productivity without a sacrifice of some other kind of productivity. In the future much more attention will have to be paid to the productivity of other factors of production such as energy and capital even if it means a fairly substantial sacrifice in the growth of labor productivity. Natural resource scarcity, in the final analysis, is not only a serious problem at the present time but may very well constitute mankind's most enduring problem. After 2 years of rather inexcusable procrastination Congress has finally passed a major

*Professor, Department of Economics, State University of New York at Albany.

energy bill. While this bill can be considered a step in the right direction, much more can and should be done to encourage energy conservation and to reduce our consumption of domestic oil and gas—two of our most valuable and scarcest resources—both of which will be largely exhausted before the turn of this century.

The recent slump in productivity has not only helped to reveal a serious food and energy problem but has also helped to initiate a new and rather virulent type of cost-push inflation which could get worse as the U.S. economy returns to a condition of full employment and productivity again slumps back to a more depressed rate of increase that will gradually decline to zero and perhaps even become negative on the average before the turn of this century.

While price and wage controls were not overineffective at reducing inflation, they did create a climate in which it was possible for our monetary and fiscal authorities to largely forget about inflation and concentrate their attention on the problem of expanding output. In the 32-month period from August 1971 to April 1974 more than 6½ million new jobs were created in the civilian sector of our economy. This was by far the best record of employment gains for any 3-year period in the history of the United States. During the first 2 years of this control period output per hour for all persons employed in the private economy also increased at an above-average rate of more than 3 percent per year.

Our knowledge with regard to how to promote improvements in productivity is rather meager and, in terms of certainty, about on a par with our knowledge of how to control inflation. The large amounts of unemployed resources which now exist in the United States and the high degree of positive association which has existed over time between changes in productivity and changes in total output would suggest, however, that the most effective way to increase productivity in the next year or two will be to adopt those fiscal, monetary, price and wage measures that are likely to be the most effective at reducing unemployment.

Achieving a condition of reasonably full employment in the near future will not be nearly as easy as was the case in the last decade when State and local governments were employing more than one quarter of all new job applicants. The near-term employment outlook for young blacks and some of the more disadvantaged members of our society is especially bleak. For those persons without jobs kills or with other disabilities that might condemn them to a chronic condition of being on public welfare, I believe that Congress should seriously consider the possibility of becoming an employer of last resort. For without some actual work experience and an opportunity to develop new skills it is doubtful if some of these persons will ever become productive citizens.

As one moves from a concern over macroeconomic policy to a consideration of microeconomic measures it seems clear that there are many actions which Congress could take to improve the efficiency of resource utilization. It is rather difficult and perhaps even dangerous to generalize, however, since the various sources of improved productivity are not really independent of each other. Modern aircraft are noted for speed but would never have risen from the ground without the invention of more efficient internal-combustion engines that can be scaled up to an almost unbelievable horsepower rating.

Education is certainly important but if additional expenditure for vocational education simply prepared young men and women with outmoded skills for jobs that do not exist it might be counterproductive.

One would hope that additional spending on R. & D. might increase productivity but again one can't be very confident. In the health field the rapid increase in public spending seems to have been much more effective at increasing hospital costs than human life expectancy. It seems clear that we do need substitutes for naturally occuring oil and gas. There is a possibility, however, that the Federal Government's huge prospective investment in new coal gasification technology may have already been rendered obsolete by prospective improvements in electric heat pumps. About all that one can say with confidence is that each and every proposal and strategy for improving productivity must be carefully analyzed on a case-by-case basis.

While the National Commission on Productivity and Work Quality has done a reasonably good job of highlighting areas where productivity can be improved, there is a larger sense in which the promotion of productity can be considered too encompassing, too complex, and too important to be left to one small Commission. In the remainder of this decade, I would hope that Congress will reexamine all of its own expenditure programs, our national tax system, and the numerous Federal regulatory bodies that may now be inadvertently fostering inefficiency and impeding gains in productivity that are socially desirable.

Productivity, by itself, however, is not something that a rational economist would choose to maximize. Large reductions in one input can sometimes mean only a modest increase in total welfare if the reductions are in large measure offset by increases in other inputs. The evidence, moreover, would strongly suggest that it is becoming far more difficult to invent new products and discover new productive processes that are unambiguously superior to existing products and production techniques.

Since the substitution of one input for another is likely to be of even greater importance in the future than it has been in the past, it would be my guess that the great political controversies of the next decade will continue to center around instances of either too much productivity or not enough of the right kind of productivity. Productivity in the municipal bond underwriting profession, for example, has been so high in recent years as to not provide investors with adequate protection against hidden operating deficits and a rather serious problem of unfunded pension liabilities.

Output per man-hour in the railway industry and in some of our central city rental housing markets has been kept high in some cases, as a result of too little maintenance. Labor productivity in the bituminous coal industry has also been excessive because of an inability on the part of Congress and the administration to agree on a strip mine reclamation bill which will be needed to preserve the longer run productivity of our land resources. Health is another area where the answers to some of our most serious problems may very well imply less productivity rather than more.

In its haste to improve the quality of the environment Congress has created a subsidy system which encourages suburban sprawl, wastes land, and dissipates both human and nonhuman energy resources.

In our efforts to develop a social security system that is almost entirely financed by employee and employer contributions we have inadvertently created an environment which discourages employers from hiring older workers, students, and part-time and disadvantaged persons whose productivity is suspect as being below average. This is clearly an area where new policies and financial arrangements are called for even if it means some sacrifice in the growth of labor productivity. In the last section of this paper I will suggest a possible solution to this problem and will also consider some other cases where new policies may be required to ameliorate imbalances in the use of other scarce resources.

Part I. Some Reasons for the Productivity Slump

Output per man-hour in the private domestic economy appears to have increased at an increasing rate during the first half of this century and been subject to a condition of retarded growth in the last 25 years. One of the most dramatic ways to illustrate the productivity slump is to divide the 25-year period from 1947–73 into three subperiods which bridge years of peak prosperity. When this is done we obtain average annual growth rates for output per man-hour of 4.1, 3, and 2.1 percent respectively for the subperiods, 1947–53, 1953–66, and 1966–73.[1]

Output per employed hour in the private domestic economy fell almost 5 percent from the first quarter of 1973 to the fourth quarter of 1975 and did not recover to a new high until about the first quarter of 1976. The evidence would suggest, moreover, that the recent increase in productivity has been substantially less than in previous recoveries.[2] While I would expect productivity to rise to new highs in the remainder of this century, there is considerable evidence to suggest that the U.S. economy is now in the process of adjusting to a more or less stationary economy and that future gains in productivity will be quite limited.[3]

Some of the most convincing evidence in support of an end to economic growth in the not-too-distant future is related to such basic dimensions of technological progress as speed, scale, and the efficiency of converting energy into useful working effects.[4] When productivity is viewed from this perspective, it becomes clear that there are inherent limits to further growth which may provide a more important set of reasons for the recent productivity slowdown than such well-publicized scape-goats as absenteeism, featherbedding, work stoppages, high rates of labor turnover, changes in the composition of our labor force, pollution control expenditures, and natural resource scarcity.

Speed

Speed is not only symbolic of a progressive economy but one of our more important sources of productivity as well. On the basis of changes

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[1] *Economic Report of the President*, January 1976, p. 207.
[2] Albert L. Kraus, "Jobs Outpace Productivity, Reviving Fear of Inflation," *The Money Manager*, June 1, 1976, p. 2.
[3] Edward F. Renshaw, *The End of Progress*. North Scituate, Mass. Duxbury Press, 1976.
[4] See, Edward F. Renshaw, "The Substitution of Inanimate Energy for Animal Power," *The Journal of Political Economy*, June 1963, pp. 284–92.

which have occurred in the transportation industry, it is not unreasonable to suppose that between one-third and one-half of all improvements in labor productivity in this century may have been either directly or indirectly the result of faster traveltimes and speedier production processes. Speed is one area where evidence in support of retardation and diminishing returns is easy to obtain and where economic limits have already caused retardation in the growth of labor productivity.

A man or a horse, for example, cannot move heavy loads long distances at speeds of more than about 2½ miles per hour. A modern diesel engine, on the other hand, is capable of moving much heavier loads at speeds in excess of 50 miles per hour—a twentyfold increase. The advantage of higher operating speed is twofold. Savings accrue not only in the form of labor and traveltime inputs but also in the form of interest and amortization of fixed capital. Within fairly wide ranges, horsepower is the only input of consequence that must be increased in proportion to total output.

While transportation might be considered only one of several industries, there is a sense in which better roads and faster traveltimes have helped to greatly increase labor productivity in other industries. Health is a classic example. The comfort and convenience of the private automobile has made it possible to move most patients to the doctor or a hospital and greatly improve the productivity of the medical profession in comparison to a system in which doctors spent most of their time traveling to see their patients. This sort of transition, of course, is a one-time improvement. As the productivity benefits associated with moving patients to doctors have been used up there has been a tendency for the price of medical care to soar.

One of the main drawbacks to higher operating speeds is that the work performed usually requires an expenditure of relatively more energy. A modern destroyer can cruise at speeds up to 35 knots per hour for short periods of time. Rough calculations by George Manning indicate that a further increase in speed to 38 knots without sacrificing any other military characteristics would require an increase in displacement of 33½ percent and an increase in fuel consumption at cruising speed of 21 percent—all for an increase in speed of less than 10 percent.[5] Significantly higher operating speeds for surface ships are impossible without resorting to hydrofoils or hovercraft which are more costly in terms of capital outlay and also have low-propulsion efficiencies.

Whether faster traveltimes should be considered more, instead of less productive, depends on an important way on how society chooses to value fossil fuels. As liquid hydrocarbons become increasingly scarce, there will be an economic incentive to shift from air to ground and water transport, to reduce the size and speed of private automobiles, and to make better use of public transport even if it means more waiting and great traveltime. All of these economizing measures will tend to lower labor productivity either directly or indirectly. Whether they can also be expected to reduce economic well-being is more conjectural.

While speed, as much as any factor, probably accounts for many of the revolutionary changes which have occurred in the last century, it

[5] George C. Manning, "The Theory and Technique of Ship Design," John Wiley, 1956, p. 46.

is not an unmixed blessing. The capability of the average automobile is already so great that much effort must be directed toward reducing and controlling ground speeds in the interest of safety and accident prevention.

The problem of unsafe speed is not unique to the transportation sector. Damage occurring to goods in process and delays resulting from equipment breakdown are two of the most important reasons why the average worker in manufacturing industries was employing less than six horses in 1972 compared to the hundred or more horses under the hood of the automobile that may have been used to bring him or her to work. The speed characteristics of the average farm tractor, interestingly enough, are not very different from those that can be supplied by a live horse.

As the limits to practicable working speeds are reached in most industries—a development which can easily be envisioned as occurring before the end of this century—the growth in output per man-hour can also be expected to stop unless it is possible for workers to operate a larger machine, expand their control over more and more machines which are operating at the same rate of speed or make more efficient use of the available machines.

Scale

One of the most important differences between inanimate prime movers and animals is the possibility of teaming together hundreds of mechanical horses in a smaller space than was formerly required to house and harness one live animal. The compactness of the mechanical horse profoundly affects the scale of productive operations. The load or scale factor is of particular economic importance since the cost of adding additional mechanical horses, at the design stage, and especially the cost of housing, caring, and driving them after they have been incorporated into an engine are, within wide ranges, less than proportional to the number of horses added.[6]

Larger machines are perhaps our most important source of increased productivity. The economics of big machines start to cut two ways, however, as the market for them narrows and development costs must be spread over fewer units. Shipments of huge pieces of equipment can butt up against the hard realities of rail and highway underpasses. In some areas, equipment designers have just about reached the limits of the available materials and components. Reliability standards intensify as the user tries to insure the success of his enormous financial commitment. Big Alis, Consolidated Edison's largest generating unit, is an interesting example. It could supply about 10 percent of Con Ed's power demand but because of reliability problems and the difficulty of replacing that much electricity on short notice if the unit were unexpectedly forced out of service it has generally been operated at much below full capacity.

As plants get larger and production becomes more concentrated in fewer and fewer plants it is often necessary to move materials and finished products longer distances on the average. The higher costs for transportation will tend to offset economies of scale at the plant. Public policy, in the form of concern over excessive pollution, noise or safety, may also intrude and prevent such plants from either being built or sited in an optimal location.

The larger the ship, other things equal, the smaller the fleet and the fewer the trips required to deliver a given quantity of output. If

[6] "The Substitution of Inanimate Energy for Animal Power," op. cit., p. 287.

time is not to be lost in port, the horsepower of the unloading facilities must be increased in proportion to the size of the ship; but because of fewer trips this horsepower will tend to be idle a larger fraction of the time. Greater inventory will be required between ships; and, since some ports are not equipped to handle large ships, additional losses are likely to exist as a result of greater "roundaboutness" in the transport of people and commodities. It might also be noted that as less frequent and more marginal activities of the human operator are mechanized, one automatically increases the idleness of added horsepower and increases the number of gadgets that might fail and possibly idle the entire complex.

In the 1960 Yearbook of Agriculture it was noted that because many time losses tend to be proportional to area, an increase in width or speed of a machine cannot be expected to result in a proportional increase in effective field capacity. In popular articles emphasizing technology and economies of scale one now finds more emphasis on barriers to progress and statements such as that of K. W. Anderson and John Deere, "In farm equipment, a 24-foot harvester is about as wide as you can go."

Automation

With machine size determined by unwieldiness and/or the size of package consumers prefer, the hope for further substitution of inanimate energy for muscle power rests on better integration of complementary machinery and the elimination of machine tenders. While it is possible to visualize computers and other electronic devices taking over routine control functions, automation seems more likely to give the average worker less to do than to eliminate him completely since repairs must be made and normal stoppage corrected. Consider for a moment the case of agriculture where the introduction of bigger and better machines employing more and more horsepower has, until recently, created a condition of almost chronic underemployment.

The operation of farm tractors by means of radio control devices has been under study since, perhaps the mid-1920's. It was soon found, however, that the extreme variability of farm operating conditions are not conducive to efficient programing and remote control. Even if it were economically feasible to collect and transmit enough information about differences in agricultural terrain to make remote control as technically efficient as control by a human operator, there still would be the problem of accidents and normal downtime requiring the services of an on-the-spot attendant. With tens of thousands of dollars invested in a piece of complicated harvesting equipment and only a week or so to put up a crop, farmers are unlikely to be willing to run the risk of either not having pertinent information at their fingertips or not being in a position where it is possible to respond in a creative and constructive manner to unexpected information.

Greater opportunities exist for adapting electronic controls to complex industrial processes but with half a million dollars' worth of digital and analog computers replacing perhaps one supervisor in a refinery or power station, it is rather difficult to imagine far-reaching repercussions. In most cases the main justification will be improved operating efficiency which tends to be inherently limited by natural laws. If an allowance is made for fabricating and maintaining the

control equipment, it would not be at all surprising if elaborate controls created more jobs than are directly eliminated.

The Efficiency of Converting Energy Into Useful Effects

The third most important source of increased productivity, in my judgment, is improvement in energy conversion efficiency. Claude Summers has estimated that the efficiency with which fuels were consumed for all purposes increased by a factor of about four between 1900 and 1970. An increase in conversion efficiency not only saves fuel but also saves corresponding amounts of labor and capital that would otherwise be employed in mining, transporting, and utilizing our energy resources. One of the main reasons for supposing that there has been a fundamental change or reduction in the long term growth of labor productivity is that it has not become much more difficult to improve the efficiency of devices which convert fossil fuels and electricity into comfort heat, cooler temperatures, and useful working effects. The limits to conversion efficiency are well understood in the case of heat engines and electrical generators and are rapidly being approached.

The peak in the efficiency of new fossil-fired electrical generating units, for example, was apparently reached around 1967 with the installation of a generating plant having a heat rate of 8,652 Btu's per kilowatt hour. Further improvements in conversion efficiency will depend upon higher temperatures and pressures which require costly alloys and are still limited by natural laws.[7]

Improvements in the efficiency of converting raw energy into comfort heat and useful working effects allowed our gross national product in constant dollars to grow more rapidly than the consumption of mineral fuels between 1920 and 1965. The slowing down of improvements in conversion efficiency in recent years not only caused energy consumption to grow more rapidly than GNP from 1965 to 1973 but also helped to set the stage for a rapid increase in energy prices which may already have brought the era of rapid economic growth in the United States and other energy poor industrialized nations to an end.

The Price of Energy and Its Effect on Productivity

In their book on "Scarcity and Growth," Harold Barnett and Chandler Morse note that there has been a certain tendency to regard technological advance as a chancy phenomenon or "a bit of luck that is sure to run out sooner or later." As an example of this view they note that Alfred Marshall conceived the law of diminishing returns to be a historical law that was only temporarily set aside by the industrial revolution and the opening up of new lands. In the words of Marshall:

> The world is really a very small place * * * and there is not room in it for the opening up of rich new resources during many decades at as rapid a rate as has prevailed during the last three or four. When new countries begin to need most of their own food and other raw produce, improvements in transport will count for little. From that time onward the pressure of the Law of Diminishing Returns can be opposed only by further improvements in production and improvements in production must themselves gradually show a diminishing return.

[7] "The 1970 National Power Survey." U.S. Federal Power Commission, 1971, pt. IV–1 p. 10.

Barnett and Morse are inclined to reject the view of Marshall and accept the premise that technological progress is self-generating. They suggest that:

> A strong case can be made for the view that the cumulation of knowledge and technological progress is automatic and self-reproductive in modern economies, and obeys a law of increasing returns. Every cost-reducing innovation opens up possibilities of application in so many new directions that the stock of knowledge, far from being depleted by new developments, may even expand geometrically. Technological progress, instead or being the adventitious consequence of lucky and highly improbable discoveries, appears to obey what Myrdal has called the "principle of circular and cummulative causation"; namely, that change tends to induce further change in the same direction.

In an article which was published in a 1974 issue of the *Brookings Papers on Economic Activity* Professor Nordhaus, an economist at Yale University, discusses an econometric model which gets the United States through at least the next two centuries without any significant slowing of the long-term growth rate due to a shortage of energy. His basic model assumes that society will be able to leapfrog from technology to technology in the decades ahead as lower cost energy sources are exhausted and give way to higher cost sources. Beyond the next two centuries he is counting on breeder nuclear reactors and other new energy technologies to carry our economy into the indefinite future.

The main thrust of the Nordhaus study is that "we should not be haunted by the specter of the affluent society grinding to a halt for lack of energy resources." As Leonard Silk of the New York Times has commented, "In these gloomy days, every bit of cheer is gratefully received—at least until the opposition knocks it down."

The Nordhaus model, like most other growth models that have been examined by mathematical economists in the last three decades assumes that the growth rate of technical change is of the nature of a compound rate. If one starts with this assumption and also assumes that capital investment is a very good substitute for other resources such as labor, land, energy, pure water, clean air and a dirty environment, economic growth will go on forever. For on the basis of the assumptions that have been built into the model, there is simply no way that it can ever grind to a complete halt.

The only possible justification for seriously considering such models is the fact that labor productivity and other measures of technical change do seem to have increased at a compound rate until fairly recently. The historical data could just as easily be consistent with many other types of technical changes, however. Many of the S-shaped growth models which are employed in biology, for example, have a compound growth phase. Assuming that the S-shaped curve is symmetric, it would generally not be easy to distinguish between it and the Nordhaus model until after the golden age of technological change was more than halfway over.

The main problem with the unlimited progress hypothesis is that futuristic technologies do not always live up to their original promise. Atomic energy, after several billions of dollars of research effort and more than 30 years of fairly intensive development is still a minor source of electric power and not something that can easily compete with fossil fuels on a favorable cost basis in those parts of the world that are blessed with an abundant supply of coal.

It should also be noted that the present generation of atomic reactors are rather inefficient at converting nuclear energy into electricity and are dependent upon an energy source that is not very abundant in nature. We are now mining ores where the concentration of uranium is between 1,000 and 3,000 parts per million. The mean abundance of uranium in the earth's crust, however, is only 4 parts per million. It might be noted that the price of uranium has more than tripled in the last year or two. If it were to become our principal source of energy, its price could reasonably be expected to eventually rise a thousand fold or more.

Nuclear fusion is sometimes considered to be the ultimate solution to our energy problems. The technical difficulties of containing and controlling a hydrogen explosion are so great, however, that most scientists are not confident that it can ever be accomplished. And if the technical problems are surmounted and a device is built which produces more power than it consumes, it doesn't necessarily follow that such a device would be economical. Our efforts to put a man on the moon have shown that a lot of interesting new technology can be developed that is not of much practical value on earth. The last three decades of rather intensive effort to develop new energy conversion devices and exploit other sources of energy, besides fossil fuels also provide at least as much ground for pessimism as for optimism.

What we do know with certainty is that it is becoming more difficult to improve the efficiency of converting energy into useful working effects and that in the absence of further improvements, the energy cost of extracting additional energy and materials from the crust of the earth can be expected to increase.

From our efforts to treat wastewater we know that as the percentage of organic material removed increases, the cost of waste treatment increases not in proportion to the percentage of BOD removed but at a rapidly increasing rate. The same phenomenon has been observed in connection with petroleum reservoirs and must surely hold in the case of most other mineral resources.

Crude oil at $12 per barrel is still only about a tenth as expensive per calorie as vegetable oil at 40 cents per pound. As existing and yet to be discovered supplies of liquid hydrocarbons are used up, the caloric price of crude oil will eventually rise to equal and perhaps exceed the price of vegetable oil, which is more perishable and not as good a source of materials for some essential chemicals. This would suggest that price of crude oil will eventually rise to more than $100 per barrel.

Some utilities have recently paid as much as $30 per ton for new coal supplies. For some metallurgical purposes coal is worth as much or more per calorie as crude oil. For those purposes, coal would be worth $452 per ton if crude oil is assumed to sell for $100 per barrel.

While coal is relatively abundant and may not rise to such levels for many years, we do have a more immediate problem with respect to oil and natural gas which currently supply more than three-quarters of our total energy consumption. One reason for supposing that the downward trend in the growth of labor productivity will continue and perhaps be even more dramatic in the remainder of this decade than was the case from 1966–73 is evidence in these two industries which suggests that the United States has been living off of productivity gains which, in a sense, were borrowed from the past.

Natural gas production, in terms of Btu's surpassed petroleum production in 1963 to become our No. 1 source of domestically produced energy. In 1973 it provided almost a third of our energy consumption. Our reserves of natural gas were very large in relation to total consumption in the early post World War II period and continued to increase each year until 1967. In the years since 1967 the net additions to our reserves have been less than half as large, on the average, as our consumption. By drawing down our reserves we have been able to keep output per person engaged in natural gas exploration at over twice the level that would probably have prevailed if consumption were cut back to equal new reserves or if drilling activity were expanded enough to equal consumption.

Our petroleum industry is in a similar situation. In 8 of the 13 years prior to 1974 annual reserve finds for crude oil in the United States were less than annual production. Total oil production reached an all-time peak in 1970 and has since been trending downward. It was not until April 1972, however, that the Texas Railroad Commission increased the allowable oil production from wells in our largest producing State to 100 percent of their so-called maximum efficient rate. Now that excess capacity is no longer available to help offset the natural decline in production from existing wells, the oil industry will have to increase its drilling activity substantially.

Since total output will not be increased by expanding drilling activity to offset production losses from old wells, it is reasonable to conclude that efforts to become more self-sufficient in basic energy production will tend to substantially reduce output per man-hours in both the oil and natural gas industries.

If higher energy prices cause business and consumers to increase their consumption of energy at a slower rate in the future, that in turn can be expected to slow the growth of output per man-hour in energy distributing industries.

Total output for the gas and electric utility industries increased at an average annual rate of 7.8 percent from 1947–72. The 6.8 percent increase in output per man-hour in these two industries was almost equal to the growth in total output. Once wires and pipelines of sufficient capacity are in place, output per man-hour can be increased by almost the same percentage as the growth of total energy consumption. If consumption grows at a slower rate in the future, it follows that output per man-hour in the gas and utility industries will also increase at a much slower rate.

The same sort of reasoning can be applied to other industries. Since there are a large number of fixed costs or motions involved in assembling and servicing automobiles, we can conclude that an energy price induced shift to smaller cars, which use less gasoline per mile, will tend to reduce labor productivity in both the automobile manufacturing and servicing industries.

One could go on and enumerate many other ways in which higher energy prices might be expected to retard improvements in output per man-hour. One of the more effective ways to save energy is to reduce the speed of trucks, automobiles, ships, and airplanes. This in turn will tend to reduce the productivity of salesmen, truckdrivers and other providers of transport services.

The important point, it seems to me, is that the United States and other nations, which are dependent upon oil imports for a significant share of their energy needs, are not likely to grow as rapidly in the future as was the case before the oil embargo of 1973. The process of adjusting to a no growth economy, in other words, is already upon us and is not something that can be postponed until we have solved all our economic problems, exhausted standing room, depleted most of our high grade mineral resources, drowned in our own industrial wastes, or approached a worldwide heat limit which will not permit life to be sustained on earth.

Part II. Technology, Environmental Quality, the Demand for Services and the Productivity of Other Resources

In this section we will continue to examine the productivity slump as well as the prospects for further increases in output per unit of input by first considering new technology and later considering its differential impact on the service sector of our economy. The remainder of this section will focus on the efficient utilization of such important economic inputs as capital, labor, energy, agricultural land, and expenditures for pollution abatement. Evidence compiled in connection with all of these input dimensions tends to further support the law of diminishing returns and the hypothesis that the United States and other industrialized nations are nearing an end to economic progress.

Technology

Federal expenditure for research and development, as a percent of GNP and the Federal budget, trended downward from 1965 to 1975. This has caused many scientists, as well as some economists, to forecast a slower rate of growth for our gross national product.

In the case of space research there has been a noticable loss of enthusiasm for additional expenditure with most persons realizing that there isn't much of economic value on the Moon or any great urgency for human beings to make a trip to Mars. In the area of national defense there also seems to have been a change in attitude with more Congressmen appreciating that a never ending stream of newer and fancier weapon systems may be a poor substitute for the kind of hard negotiations that will be necessary to secure a lasting peace.

If expenditure on behalf of new weapons systems and space exploration are removed from the budget, however, an opposite impression is obtained. Federal expenditure for civilian research and development, as well as private expenditure on R. & D., have both been increasing at least as rapidly, on the average, as our gross national product since 1965 and in some recent years quite a bit faster.

This is not the only factor which should have helped to create a condition favorable to an accelerated growth in economic activity in the last decade. In the 8-year period from 1965–73 almost twice as many persons were added to the ranks of our employed civilian labor force as was the case from 1957–65; the share of GNP devoted to gross private domestic investment increased slightly after having accelerated dramatically from the stagnant levels experienced from

1957–61; and the educational attainment of our employed labor force also continued to increase at a very impressive rate. With all of these conditions favoring an accelerated increase in the GNP growth rate it is indeed surprising to note that the growth rate for real GNP actually declined slightly from 1965–73 compared to 1957–65 and that growth in output per man-hour in the private domestic economy plunged significantly.

An implication, it seems to me, is that persons engaged in research and development are now finding it more difficult to discover and invent new products and productive processes that are unambiguously superior to older commodities and ways of producing goods and services.

Almost all of the great new technological innovations in the last decade seem to be in the material and capital goods area. But progress can be quite limited even in this area. In 1957 Douglas Hague noted that the concerted efforts of the hundreds of scientists who have examined thousands of possible products during the last 25 years have led to only five classes of synthetic fibers. "Introduction of a structurally different fiber is a rare occurrence."

The mid-third of this century is now considered by some scientists as the golden age of medicine because of such important developments as the discovery of antibiotics, surgical invasion of the heart, kidney transplants, and the unmasking of viruses. But the pace has slowed considerably in the last decade, with relatively fewer new drugs of a chemically distinct character being marketed in most years. This would appear to support a 1970 warning by Dr. Ernst Chain, codiscoverer of penicillin, that there may be few rabbits left in the hat.

The apparent slowdown in the pace of medical science is not something that can easily be attributed to a lack of financial support. Expenditures for research and development by the U.S. Department of Health, Education, and Welfare—which are mainly in the health area—increased almost twentyfold between fiscal years 1954 and 1969 from $63 million to an estimated $1,310 million. Improvements in life expectancy during the same period of time have slowed down considerably. From 1920 to 1950 the life expectancy of U.S. residents increased on the average by about 4.7 years per decade. In the decade of the 1950's the improvement dropped to 1.5 years and in the 1960's the improvement was only 1.1 years.

In his presidential address before the American Economic Association in 1938, Alvin Hansen noted:

> When a revolutionary new industry like the railroad or automobile, after having initiated in its youth a powerful upward surge of investment activity reaches maturity and ceases to grow, as all industries must, the whole economy must experience a profound stagnation, unless indeed new developments take its place.

To the extent that economic growth is dependent upon a rapid increase in output per man-hour there seems to be a fair amount of support for Hensen's theory of stagnation. Newer industries do tend to achieve higher rates of growth in labor productivity than older industries. A recent BLS compilation shows that air transportation, a relatively new industry, had the highest average annual growth rate for output per man-hour from 1947–73 while footwear, one of our oldest industries, ranked at the bottom of the list. Aluminium rolling

and drawing was near top of the list while steel foundries were near the bottom.

In the case of the shoe industry it seems clear that we do have in being both the technology and the machinery to greatly increase labor productivity. The only problem is that the new plastic shoes, which lend themselves to automated production techniques, really don't measure up either in terms of quality or comfort to the old-fashioned footwear made out of animal hides of irregular sizes and shapes.

As far as important new consumption goods are concerned we do seem to be suffering from a profound technological depression. Except possibly for permanent press pants, and pocket calculators, it is hard to think of any new and exciting consumption goods that were introduced in the last decade or so with a market potential close to 100 percent.

It should also be noted that new products do not seem to be replacing old products to the same extent that was once the case. Trucks and automobiles, for example, brought about a near demise of the horse population in our Nation's cities. Helicopters and personal airmobiles, on the other hand, have not led to a significant reduction in the number of private automobiles.

The net result is that we are now having to maintain relatively more duplicate and overlapping systems. Automobiles have reduced the number of transit riders but not eliminated the need for transit systems. The telephone is hurting the U.S. Post Office but cannot replace its functions altogether. Magazines and newspapers have been weakened financially by radio and TV but will probably survive. The necessity of having to maintain old systems, where productivity is not advancing at a very rapid rate, is surely one of the more important reasons for the slower overall growth in aggregate productivity.

The recent energy crisis would suggest, moreover, that we may eventually have to abandon some of the newer and more energy-intensive products and also return to earlier transportaion technologies by substituting trains for planes, and bicyclew for automobiles.

As we look to the future, in any event, it seems clear that the proportion of GNP spent on civilian research and development will have to increase rather substantially if we are to be successful at reducing our dependence upon imported energy and in developing substitutes for oil and natural gas which currently supply more than three-quarters of our total energy needs. This was once thought to be a fairly easy task.

In January 1974, after the price of imported oil was raised by OPEC to more than $10 per barrel, Government officials optimistically estimated that the United States would be able to obtain synthetic crude oil from domestic shale and coal at prices ranging from $6.80 to $7.70 per barrel. In March 1975, however, Federal Energy Administrator Frank Zarb indicated that a more realistic estimate for exotic fuels such as gasification, liquefaction, and shale oil will probably be in the range of from $14 to $22 per barrel. If these estimates are correct, the overall implication would seem to be that scientists and engineers may have to work very hard in the next few decades to simply preserve an energy-intensive way of life for the average American.

In his presidential address before the AAAS in December 1970,[8] Bentley Glass has contrasted the Endless Horizons of Vannevar Bush in 1946 with the more recent Coming of the Golben Age by Gunther Stent. The question to be faced according to Glass is: "Are there finite limits to scientific understanding, or are there endless horizons?" Stent, like Henry Adams and Roderick Seidenberg, have argued cogently that there are limits to knowledge and that cessation of scientific advances will ultimately lead to an end to technological and social progress.

If scientists and engineers have been reasonably successful at developing the easiest and most productive production processes first, then the prospects for maintaining an affluent way of life may not be very favorable at all.

To postulate an end to improvements in real per capita income in the near future, however, it is not necessary to believe in an early end to improvements in scientific understanding and technological knowledge. All that is required is that an increasing share of the benefits from improved technology be devoted to such objectives as offsetting natural resource scarcity, maintaining the quality of our environment, making working conditions safer and more enjoyable and increasing the amount of leisure time that is available to the average workers.

Pollution

While there is not much doubt that the environmental revolution will tend to reduce present measures of productivity in the long run, it is not entirely clear that there has been a net overall lowering of national productivity so far. The large indrease in demand for pollution control equipment has surely helped to increase productivity significantly in those often new industries supplying goods and equipment to reduce air and water pollution. These goods are a component part of real GNP. It is not until new plant and equipment is placed in operation that one would expect a diminution in measured productivity.

Since most of the investment in new sewage treatment plant and collector systems has been by State and local governments, where all expenditures are considered to be output and little or no effort is made to measure productivity change, it seems clear that our principal method of financing and accounting for water pollution control expenditures will tend to minimize the adverse impact on measured productivity. By keeping investment demand high in a period that was generally characterized by excess capacity and inadequate consumer demand, the net overall effect of the environmental revolution on the rest of the economy may have been to boost the growth rate for real GNP and increase output per man-hour rather than reduce it.

Improvements in the quality of the environment can also be made in some instances without an investment in pollution control devices. In New York City and some other metropolitan areas there has been a rather striking reduction in the amount of sulfur dioxide emissions since 1966 as electric utilities have shifted from coal to the burning of low sulfur oil derived from the refining of imported oil. This sort of substitution may have boosted the overall productivity growth rate considerably since the growth in output per man-hour in the

[8] Bentley Glass, "Science: Endless Horizons or Golden Age?" *Science*, Jan. 8, 1971, pp. 23-29.

petroleum refining industry has remained very high in recent years while the growth in output per man-hour in the bituminous coal industry has either been relatively stagnant or negative since the enactment of the Health and Safety Act of 1969. (The productivity slump in the coal industry would suggest that mandated efforts to improve the health and safety of American workers may have had more of an adverse effect on the growth of productivity in some industries than mandated investments in pollution control equipment.)

The costs of a cleaner environment have generally been rather modest from an overall economic point of view. The new catalytic converters that have been placed on 1975 automobiles, for example, only cost between $100 and $150. They enter real GNP directly, for the most part, and are expected to reduce unburnt hydrocarbons more than 90 percent compared to 1967 models, carbon monoxide 83 percent and nitrogen oxides 48 percent. By permitting automobile manufacturers to retune their engines for better fuel economy they are also expected to increase average fuel efficiency about 14 percent compared to 1974 models.

In 1974 the President's Council on Environmental Quality released a study which suggests that environmental programs in the United States had accounted at most for roughly one-half of 1 percent of our inflation, 1 percent of our gross national product, 2 to 3 percent of all investment expenditures and 5 to 6 percent of total expenditures on industrial plant and equipment.

These cost estimates could escalate rather sharply if industries were required to stop polluting altogether.[9] It does not seem likely, however, that Congress and the administration will push our environmental goals to the irrational point of requiring zero discharge in most instances. In pollution control, as in all other areas using scarce economic resources, a reasonable balance must eventually be struct between the benefits to be expected from a cleaner environment and the cost of achieving that objective.

While I would not expect pollution to be a very serious constraint on productivity in a world supplied with an abundance of natural gas and low sulfur oil and coal, it could become a more serious constraint in a world of increasing natural resource scarcity.

In a pioneering analysis of coal's environmental debt, Gerald Garvey has examined some of the economic costs associated with land subsidence, uncontrolled fires in abandoned mines, acid mine drainage, and the need for greater earth waste reclamation and soil conservation in Appalachia. He concludes that at least $4 billion would have been required in 1970 to correct cummulative damages and achieve something approaching a full environmental restoration of abandoned coal mines in the United States and their unsightly waste heaps.[10] This debt, interestingly enough was slightly greater than the economic value of the coal which was mined in 1970.

Coal presently supplies less than 20 percent of the energy used in the United States. The cost of rectifying environmental damage can be expected to increase at a rapid rate as we replace oil and gas with synthetic fuels derived from coal and shale, however, since coal is a

[9] "Chemical, Paper and Metal Industries Say Economy Will be Hurt by Costs of Achieving Zero Pollution." *The New York Times*, Dec. 8, 1975, pp. 53-54.

[10] Gerald Garvey, *Energy, Ecology, Economy*. Norton, 1972, p. 88.

dirty compound and since relatively more energy will be used up in mining, processing, upgrading, and transporting synthetic fuels to consumers. The problem of maintaining a reasonably clean environment will also be exacerbated in the future by the fact that most of our remaining fossil fuel reserves are presumed to be located either offshore, where oil spills are a problem, or in places with fragile ecologies such as Alaska and the arid West where the environmental damage may turn out to be much more severe.

Natural resource scarcity does have a silver lining, however, in that higher prices for energy and materials will make it more profitable to reclaim solid and some liquid wastes for fuel and basic materials. The problem of old junk automobiles littering the countryside and some city streets is not nearly as great as it was a few years ago. The State of Connecticut, which has become a leader in the field of recycling, expects to recover enough steel from trash and garbage by 1985 to build 20,000 tons of products, and enough fuel to generate 10 percent of the State's total energy needs.

The Service Economy

Total employment within the service sector of our economy, which includes transportation, public utilities, wholesale and retail trade, government, hospital and doctor's services, finance, insurance, real estate, and a variety of other services, has grown from approximately 40 percent in 1929 to over 60 percent in 1973. What was the reason for the dramatic shift of employment toward services? In his book on *The Service Economy* Victor Fuchs considers three hypotheses: (1) a more rapid growth in the demand for services by consumers, (2) a relative increase in the demand for services by businesses, and (3) a relatively slow increase in output per man in the service industry.

The first hypothesis accounted for very little of the change. Total output in the service sector in constant dollars was about the same in 1965 as in 1929. In current dollars the service sector increased its share of GNP from 47 percent to about 50 percent. The second hypothesis was examined by Fuchs and found to explain less than 10 percent of the total change. The major explanation was that output per man-hour grew much more slowly in the service sector than in other sectors. This would suggest that most service industries are inherently less subject to technological change than the rest of the economy.

In an interesting article on the anatomy of urban crisis,[11] William Baumol has argued that many of our urban problems are basically the result of differential productivity and has suggested that such differences could lead to an end of economic growth. Let us suppose that increases in output per man-hour are not the same in different industries. Let us further suppose that consumers prefer to increase their consumption of all goods by about the same proportion. The percentage of total hours worked in industries with slowly rising output per man-hour will then have to increase over time. This will cause the overall average growth rate for total output per man-hour to decline, since a larger share of the total labor force will be employed in industries with low productivity.

[11] William J. Baumol, "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis," *American Economic Review*, June 1967, pp. 419–20.

In 1971 Leon Greenberg, then staff director of the National Commission On Productivity, pointed out that the increasing importance of low productivity industries will lower the productivity growth rate in the United States by 0.2 of a percent during the 1970's. In the preceding 20 years interindustry shifts raised the growth rate by 0.2 percent. The overall result is a 0.4 percent swing which translates into a lot of GNP dollars.

In 1947, more than 18 percent of all man-hours in the private economy were expended in agriculture. By 1973, the proportion had fallen to 5.2 percent. Over the entire period about 10 percent of the growth in output per man-hour can be attributed to the shift of labor from agricultural to nonagricultural employment where output per man-hour has been higher. This shift effect was far more important in the earlier part of the period than it has been since 1967. From 1947 to 1967 the shift accounted for about half a percentage point of the average increase in aggregate productivity or about one-seventh of the total annual rate of increase. From 1967 to 1973, however, the shift only accounted for about 0.1 percentage point or about one-thirtieth of the total annual rate of increase. Part of the decline in the rate of productivity increase since 1966 is directly traceable to the declining effect of the shift of labor from agricultural to nonfarm and especially service employment, but not all of the decline.[12]

The service sector of our economy is not a homogeneous sector. Growth rates in output per man-hour in the air transportation and the gas and electric utilities industries were actually at the top of 44 selected industries studied by the BLS for the period from 1947–73. One of the main sources of productivity drag during this period was provided by State and local government employment where almost no effort is made to measure productivity change. The State and local government sector provided only 6.3 percent of all job opportunities in 1947. Its share has since increased to over 13 percent in 1973. In the last 15 years more than a quarter of all new civilian jobs have been provided by State and local governments. More than half of these new jobs were in the field of education.

The number of live births in the United States reached an alltime peak of 4.3 million in 1957, however, and has since trended downward to less than 3.2 million in 1973. School enrollments at the elementary and secondary level peaked out several years ago and with college enrollments expected to decline in the next few years, it is obvious that State and local government employment will not have to increase nearly as fast in the last half of the 1970's as has been the case in the last 15 years. The same conclusion would seem to apply in connection with AFDC and other youth-related expenditures, once our economy returns to a condition of reasonably full employment.

While the productivity growth rates for the service sector have tended to be less on the average than for other sectors of our economy, it is by no means clear that this will continue to be the case in the future. Natural resource scarcity as well as the production and maintenance of pollution control devices will tend to create relatively more jobs in the mining and goods producing sectors of our economy and will also provide a differential drag on the growth of productivity

[12] J.R. Norsworthy and L. J. Fulco, "Productivity and Costs in the Private Economy," *Monthly Labor Review*, June 1974, pp. 3–9.

as it is presently measured. It might be noted that some of our more traditional service industries, such as magazine publishing, will either have to achieve greater productivity or run the risk of being priced out of business.

Such recent and possible future developments as no-fault insurance, new automatic checkout systems for supermarkets, do-it-yourself divorce, more extensive group insurance policies, and a pill or toothpaste that really prevented dental cavities could also tend to reduce the relative size of the service sector and increase the productivity of those who remain in that sector. The high cost of gasoline, plumbers, psychoanalysts, and persons engaged in the repair business already seems to have led to a revival of self-service, group therapy, transcendental meditation, and do-it-yourself repairs. In mental health and in criminal justice the emphasis is now shifting from full-time incarceration to halfway houses, community and home-based treatment programs—innovations with a potential for significantly increasing the overall productivity of both the service sector and the economy as a whole.

The Human Factor

In the 1970 Economic Report of the President, it was suggested that the decline in the growth of labor productivity in the late 1960's may have been the result of bottlenecks, labor shortages, inexperienced workers, absenteeism, a propensity to hoard skilled workers, high labor turnover, and other factors which are mainly cyclical in character or adjustments which might be expected in connection with an inflationary transition from war to peace.

There is not much doubt that production bottlenecks and a shortage of industrial capacity can have an adverse effect upon the growth of labor productivity. Improvements in output per man-hour have always tended to be relatively small toward the end of a business expansion when industry has been operating at a high rate of capacity utilization. The highest rates of capacity utilization in manufacturing, however, were apparently achieved in the early 1950's when productivity gains were exceptionally high. Since the reported utilization rates for most industries have trended downward since 1966 it seems clear that the recent productivity slump cannot be blamed on production bottlenecks of a persistent nature.

Work stoppages were a problem from 1966–71, but the number of workers involved in these strikes as a percent of the total number of persons employed was still quite a bit less, on the average, than had been the case from 1947–53. Union membership as a percent of the total number of persons employed in nonagricultural establishments reached an alltime high of 34.7 percent in 1954 and has since trended downward to only 26.7 percent in 1972. If unions have been successful at inhibiting the use of new and improved production techniques,[13] the overall impact should have diminished rather than increased in recent years, particularly since this has been one of the focal concerns of the National Commission on Productivity and Work Quality.

Since the midsixties when the postwar baby boom began to reach maturity there has been a significant influx of younger and less experienced workers into our employed labor force as well as an upward

[13] Kendricks data for 21 U.S. manufacturing industry groups are not inconsistant with the hypothesis that unions do tend to inhibit productivity advance. See *Postwar Productivity Trends, 1948–1969*, pp. 140–42.

drift in the labor force participation rates for both males and females aged 16 to 19. Their educational attainment has continued to rise in at least a modest sort of way, however. It should be further emphasized that there was an explosive growth of job training programs during this period. Enrollment in federally funded work training programs of various sorts and the number of persons completing registered apprenticeship programs more than doubled from 1965–72. By 1969 when the productivity slowdown became most noticeable, we were also experiencing a very sizable return flow of Vietnam veterans who might reasonably have been expected to profit from their armed service training. All of these developments should have helped to compensate for a younger and less experienced labor force.

Younger workers do have an advantage over older workers when it comes to learning new skills. There are some doubts, however, as to whether skill requirements have increased in recent years. Plasterboard, factory assembled doors, windows, and the like have clearly taken much of the skill out of homebuilding. When something goes wrong with an automobile or household appliance, most mechanics and repairmen do not even try to fix a subassembly but will simply replace a defective water pump or electric motor with a new or factory reconditioned unit.

Even today, with the emphasis on chemistry and electronics, it is rather difficult to find processes and machines which require operators and repairmen with a college education. A 1958 study by James Bright found that automation does not necessarily result in higher work force skills and may even tend to require less operator skill after certain levels of mechanization are achieved.[14]

A study by Boston's Forsyth Dental Center, for example, has found that dental hygienists can be trained to drill and fill teeth in less than 1 year and only made errors in 5.1 percent of the cases. A study of practicing dentists conducted in 1967 showed a 30-percent error rate. If much of the routine drilling and filling were turned over to hygienists it seems likely that their work would be superior to that of harried dentists if for no other reason than the fact that their work would surely be subject to more supervision and inspection by a qualified observer. If estimates of labor inputs were weighted by differences in education or by the lower cost of labor, this would also tend to boost measurements of labor productivity in the dental industry even if the amount of time spent in drilling and filling teeth were the same.

Senator Jacob Javits has noted that absenteeism on grounds of illness has been increasing at an average annual rate of 2.8 percent since 1957. In 1972, there were 43.8 million hours a week, or 1.5 percent of the potential man-hours available from the full-time labor force, lost as a result of short-term absences due to illness real or asserted. Compared to the figures for the early sixties, there has been a 15-percent increase in the absenteeism rate due to illness.[15] There also appears to have been a slight increase in unscheduled personal absence from work for miscellaneous reasons from 1967 to 1972.[16] The latter increase may have been largely the result of relatively more younger workers in the employed labor force.

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[14] James Bright, "Does Automation Raise Skill Requirements?" *Harvard Business Review*, July 1958, pp. 85–87.

[15] Jacob Javits, "Reforms to Improve Working Life," *The New York Times*, April 27, 1974, p. 31.

[16] Janice Neipert Hedges, "Absence From Work—A Look at Some National Data," *Monthly Labor Review*, July 1973, p. 25.

It has been suggested that workers are more likely to "take off ill" now because of the increasing prevalence of paid sick leave. Part of the increase in absence prior to 1970, however, can be traced to an increase in work injuries. Work injuries in manufacturing trended upward during the sixties, reached 14 per million man-hours in 1967 and 15.2 in 1970. One would hope that the Occupational Safety and Health Act of 1970 may have reversed this trend.

One of the final acts of Elliot Richardson before leaving the U.S. Department of Health, Education, and Welfare was to release a report on "Work in America." The report noted that the design of jobs appears to be lagging markedly behind the enormous gains in educational attainments of the work force and the elevation in credentials required of the worker has not been accompanied by an elevation in the content of work. If anything, it is more routinized and bureaucratized, leaving less to the imagination and control of the worker.

While the opportunities for humanizing work and improving job satisfaction without a sacrifice of productivity may be rather limited,[17] it does seem clear that advocates of job reform are addressing an issue of major importance. A 15-year study for the U.S. Department of Health, Education, and Welfare has found that the greatest single factor in aging is the extent to which a person's job is satisfying. This was found to have a far greater effect on lifespan than diet, exercise, medical care, and genetic inheritance.

In "The New Industrial State," Professor Galbraith has suggested that employed persons should be accorded a wider set of options than at present between work and goods on one hand and leisure on the other. Individuals that wish to satisfy their needs for food, clothing, and simple houseroom with 10 or 20 hours of labor a week should be allowed to do so and all individuals, in return for a lower annual pay should have the option of several months' paid vacation. To fail to allow such choice—to be guided by the belief that everyone should work a standard week and year—is to make the needs of the industrial system, not the opportunity of the individual to fashion his own existence, the ruling social concern. Men who speak much of liberty should allow and even encourage it.

Flexible working hours might be considered a step in this direction. They are now a way of life in West Germany and the Scandinavian countries and are becoming widespread in Canada. Flexible schedules are reported to improve productivity by increasing the ratio of man-hours worked to man-hours paid:

> Part of the increase is due to the fact that time is no longer lost because of tardiness or short periods of unrecorded leave. In addition, many firms report that days absent decline. Sick leave is reduced because accumulated time credits, rather than "the monthly flu," can be used for personal affairs.
>
> Hours worked also are reported to be more productive, resulting in less need for overtime work. Employees are likely to leave at a "stopping point" in their work, rather than slowing down as the end of the workday approaches. Moreover, they tend to leave early when work is slack and to work later when work is heavy.[18]

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[17] For one of the most balanced treatments of this subject is by Sar A. Levitan and William B. Johnston. See, "Job Redesign, Reform, Enrichment—Exploring the Limitations," Monthly Labor Review, July 1973, pp. 35–41; and "Work Is Here To Stay, Alas," Olympus Publishing Co., 1973.

[18] Harold Wool, "What's Wrong with Work in America?" *The Monthly Labor Review*, March 1973, p. 44.

Investment

Comparative data on output per person and capital investment in the United States and other major industrial nations show that some foreign countries have significantly higher rates of productivity increase and also invest a higher proportion of their gross national product in new plant and equipment. On the basis of such comparisons it has sometimes been suggested that the United States might be able to improve its growth rate by saving and investing a higher fraction of its income.

The correlation between productivity growth rates and investment is not spectacularly high, however. In the 13-year period from 1960 to 1973, for example, Italy invested only 16.3 percent of its GNP, 1.4 percentage points more than the United States, yet was able to increase its real GNP per employed civilian almost 1 full percentage point more per year, on the average, than France which allocated 20.6 of its GNP to new fixed investment.[19] While Italy's average investment rate was less than 10 percent greater than the U.S. investment rate, its 5.6-percent productivity growth rate was almost two and one-half times as large as the 2.3-percent rate for the United States.

The fundamental advantage which Italy has over France and which most other countries have had over the United States, at least until recently, is that the absolute level of output per person has been higher in the more affluent country. By investing in essentially the same kind of new plant and equipment, Italy was in a position where it could increase the average productivity of its labor force proportionately more for the same amount of new investment.

The best ordering of productivity growth rates for Japan, Italy, Germany, France, the United Kingdom, Canada and the United States for the years 1955 to 1974, in other words, is obtained not by ranking the various countries in terms of investment rates but by ranking them in inverse order of the estimated level of real GNP per employed civilian in 1955.

Japan has invested almost twice as large a share of its GNP in new structures and equipment as the United States since 1960—28.9 percent as opposed to 14.9 percent. Until fairly recently, however, Japan's real GNP per worker was less than half as large as the real GNP per worker in the United States. If Japan's goal was to reequip as large a fraction of its labor force with the newest and most modern tools of production, then the only way this could be accomplished was by saving and investing twice as much of its income. While this sort of investment policy has enabled Japan to boost its real GNP per employed civilian from only 18 percent of the U.S. level in 1950 to an estimated 66 percent in 1974, it doesn't necessarily follow that the United States could reasonably expect to boost its productivity growth rate significantly by saving and investing a larger fraction of its income.

Part of our economic problem at the present time is directly related to over-investment in previous years. Home building, for example, has usually been among the first industries to rebound from

[19] These and other calculations pertaining to international growth rates were obtained from data presented in the *Fourth Annual Report* of the National Commission on Productivity and Work Quality, March 1975 pp. 55-56.

a recession in the post World War II period. The more than 2 million housing units which were constructed each year from 1971 to 1973, however, left builders with a large inventory of more than 650,000 unsold houses and condominiums at the end of 1974. This inventory has kept new housing starts at very depressed levels in spite of lower interest rates and easier credit. The rather precarious financial condition of most real estate investment trusts can also be attributed in part to a significant over-expansion of office and commercial space in many of our larger cities.

In their monograph on Capital Needs in the Seventies, Bosworth, Duesenberry, and Carron have concluded that there may be a shortage of savings once the U.S. economy recovers from the current recession and have suggested that the Federal Government should plan to have a fiscal surplus in the national income and product accounts equal to about $82 billion per year by 1980. If one accepts their initial assumption that the average growth rate for real GNP will be equal to 4.3 percent from 1973 to 1980 and also assumes that the capital-output ratio for the U.S. economy will remain more or less constant, then it is not illogical to suppose that there might be a capital shortage in the near future. This conclusion follows from the fact that the capital-output ratio is greater than one for the U.S. economy as a whole which means that total investment would have to increase more rapidly than real GNP for a time in order to accommodate a 4-percent growth rate. If the authors had assumed a more realistic growth rate for real GNP, on the other hand, it is questionable whether their methodology would have projected a capital shortage.

In the President's Economic Report for 1968 some charts were presented showing both the actual and potential growth rates for real GNP. Potential GNP was assumed to increase at a 3¼-percent rate from the middle of 1955 through 1967, at a 3.75-percent rate from 1963 through 1965 and at a 4 percent rate during 1967. The upward drift in the potential growtn rate was mainly the result of a faster growth rate for the labor force. With this factor in mind and on the assumption that the productivity of the employed labor force will continue to increase at about the same rate as was the case on the average from 1953 to 1966 it has been a common practice for economic forecasters to assume that our potential long-run growth rate is still in the vicinity of 4 percent or more per year.

A pragmatic examination of the actual trend in real GNP since 1953, however, shows growth rates of 3.6 percent for the years 1953 to 1966 and a rate of only 3.3 percent from 1966 to 1973. In the latter period all of the increase in potential GNP arising from a faster growth rate for the labor force was more than offset by a slower growth rate for labor productivity.

The population aged 16 and over from which our labor force is recruited, has been increasing at an average of about 1.7 percent in recent years. This rate peaked out in 1973, however, and will decline to less than 1 percent by 1984 owing to the large drop in the number of births from 1957 to 1973. With other factors such as the labor force participation rate, the unemployment rate and labor productivity remaining about the same, this would be sufficient to lower our

economic growth rate from 3.3-percent average rate observed from 1966 to 1973 to only about 2.5 percent in the space of about one decade. If we assume that labor productivity will be subject to further retardation in the decade ahead, the growth rate for real GNP could easily fall to about 2 percent by the mid-1980's. This, in turn, would help to reduce the need for new investment.

Kendrick's data for the private domestic economy is consistant with the notion that output per unit of real capital input did remain remarkably constant from 1948 to 66 if an adjustment is made for fluctuations in capacity utilization.[20] Real fixed investment per dollar of real GNP rose from 14.5 percent in 1966 to almost 15.2 percent in 1973. This increase can be more than explained, however, by a somewhat more rapid increase in the employed labor force. The growth in real capital investment per worker appears to have slowed rather appreciably in the last decade as one would expect in a world where output per worker and real wages were no longer increasing at a rapid rate and providing a strong economic incentive to substitute more capital for labor. When investment is viewed from this perspective it is not unreasonable to suppose that a productivity slump might actually reduce the need for additional investment per worker rather than create a capital shortage. When we look ahead to the late 1970's and early 1980's, when the U.S. labor force will be growing at a much slower rate than has been the case in the last decade, one is confronted with the haunting possibility of a persistant, surplus of financial savings that cannot be profitably invested.

It has sometimes been suggested that natural resource scarcity and the need to become more self-sufficient in basic energy might create a serious capital shortage in the future. While there is not much doubt that new supplies of oil and natural gas will require more investment per unit of energy produced than our existing reserves it is by no means clear that this will lead to a near-term shortage of investment capital. Mining is still a very small part of our total economy. Expenditures for new plant and equipment in the mining sector have been increasing at a rapid rate but only constituted about 4 percent of total plant and equipment expenditures in 1975.

Synthetic fuel enterprises are known to be highly capital intensive. When it becomes economical to convert coal and oil shale into synthetic gas and liquid hydrocarbons, the United States may be confronted with a capital shortage. It is important to realize, however, that much of the technology which energy companies plan to use in the manufacture of synthetic fuels has not been developed beyond a pilot-plant stage. Actual costs are uncertain. Environmental constraints, technological delays, and the need for water and other kinds of infrastructure development in the arid West where large supplies of shale and low-sulphur coal are readily available could easily delay the advent of a significant synthetic fuels industry for more than a decade.

Energy

Productivity in the United States, until fairly recently, has been almost synonomous with improvements in labor productivity. In the future, much more attention will have to be paid to the pro-

[20] John W. Kendrick, *Postwar Productivity Trends in the United States, 1948–69*, p. 52.

ductivity of capital, energy, and other nonlabor factors of production even if it means a fairly substantial sacrifice in the growth of labor productivity and real wages. The productivity of energy is of particular concern, not only from a natural resource scarcity point of view, but also because Btu's of heat energy consumed per dollar of real GNP in the United States have increased in the last decade.

Studies by legislative committees and agencies of the U.S. Government, which were made before the Arab oil embargo of 1973 suggest however that only about 40 percent of the energy consumed in this country is used for productive purposes with the remaining 60 percent being wasted.[21] After examining energy consumption for different countries and the conservation measures that could be taken in the future, Makhijani and Litchtenberg have concluded that a 37-percent reduction in per capita energy consumption is possible in this country by the year 2000 without reducing the standard of living.[22]

A zero energy growth scenario developed by the Ford Foundation's energy policy project also supports the hypothesis that it might be possible to achieve further improvements in economic and material well-being in the United States without an increase in per capita energy consumption.[23] It will not be possible to accomplish this goal, though, without a substitution of other resources for energy. The benefits to be expected from a more vigorous substitution effort appear to be quite substantial, however.

A study which was prepared for the Federal Energy Office in 1974, for example, has examined opportunities for conserving energy in industry, transportation, the commercial and the household sectors of our economy and has concluded that over $400 billion could profitably be invested in increased insulation and a multitude of other energy saving devices between 1974 and 1985.[24]

These energy saving investments can be considered cheaper and more profitable than imported oil at an assumed price of $8 per barrel in 1973 dollars. They can also be considered more profitable than new domestic supplies of energy if the equivalent cost is assumed to equal $8 or more per barrel.

Energy conservation not only implies opportunities for profitable investments but also implies the creation of new jobs. Mark Seidel, an economist at the Federal Power Commission, has estimated that from $50 to $100 billion might usefully be invested in increased insulation and other home improvements that conserve energy. If the investment were made over a 6- to 12-year period, the annual cost would be about $8 billion and the number of new jobs created would total almost 1 million. Since much of the labor could be supplied by unemployed construction workers, apprentices, and persons with relatively little training it seems clear that a major conservation effort could go a long way toward helping to solve a serious unemployment problem.

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[21] "Conservation of Energy," report of the Committee on Interior and Insular Affairs, U.S. Senate, Serial No. 92-18, 1972; "The Potential for Energy Conservation, A Staff Study," Office of Emergency Preparedness, Octover 1972; "Conservation of Energy: The Potential for More Efficient Use." *Science*, Vol. 173, December 8, 1972.

[22] "Energy and Well-Being," *Environment*, June 1972.

[23] *Exploring Energy Choices*, a preliminary report by the Energy Policy Project of the Ford Foundation, 1974, pp. 51-53; and *A Time to Choose*, Ballinger, 1974.

[24] "Demand Curtailment and Conservation Scenarios," Federal Energy Office; January 7, 1974.

One of the difficulties with this solution is that many homeowners cannot afford $1,500 worth of home improvements. Those that can afford such investments and have not already insulated their home to an optimum degree may not be inclined to spend their own money for improvements that require 8 to 10 years to recover the initial investment. Elderly homeowners with low incomes, families with properties that are already fully mortgaged, and owners of basically sound housing in deteriorating neighborhoods might find it impossible to borrow for the purpose of making such investments even if they were motivated to do so.

Since private credit markets are imperfect and since energy conserving investments serve a social purpose, it would appear to be in the national interest to have the Federal Government make large amounts of special, low-interest loans available to business and individuals through commercial banks and savings and loan associations for the purpose of making cost-effective energy conservation investments that might reasonably be expected to pay for themselves in a decade or so.[25]

Natural resource scarcity, in the final analysis, is a serious problem. If a report which was published by the National Academy of Sciences in 1975 is correct, our proven and yet to be discovered reserves of recoverable oil and gas may only be sufficient to last another 25 years at present rates of consumption.

The United States, with about 6 percent of the world's population, has been consuming about a third of the world's fossil fuels and mineral wealth. Much of this consumption has been based on raw material imports from countries with low per capita incomes. The representatives of less developed countries are quite correct in pointing out that this is unfair. A recent Harris survey, moreover has found that the majority of people in this country believe that this disparity hurts the well-being of the rest of the world and is morally wrong.

One of the main advantages of the investment approach to energy conservation is that it has the potential of providing very sizable spillover benefits to other countries without depressing economic activity in the United States and forcing politicians to adopt unpopular rationing measures which might require almost everyone, regardless of circumstances, to drive less, be cold in the winter, and remain uncomfortable in the summer. By making many of those investments now which will be needed in the long run it should be possible for the United States and the rest of the world to grow faster in the short run and experience far less unemployment, inflation, and political instability than might otherwise be the case. The problem of inflation has not only been aggravated in recent years by an explosive increase in energy prices but also by stagnant agricultural productivity.

Agricultural Land

During the 4-year period from 1959 to 1963 crop yields in the United States increased at an average annual rate of 2.4 percent per

[25] To be most effective from the standpoint of stimulating economic activity, the loans should be for energy-conserving investments that otherwise might not be undertaken or completed. They could cover many items besides home insulation. Some of our atomic powerplants now stand half completed for loack of adequate financing. Those that have been started should probably be completed. It might also be desirable to extend short-term loans for energy conserving investments to other industries that are experiencing financial difficulties and to some governmental units that are unable to borrow on advantageous terms because of a deteriorating tax base. In the case of low-income households, low-interest loans might also be made available for such purposes as replacing large automobiles and appliances with smaller and more efficient vehicles and appliances.

year or more than 1 full percentage point more than in the preceding 56-year period. Toward the end of this period of explosive improvement in crop yields James Bonner analyzed factors which regulate photosynthetic efficiency and published a paper titled, "The Upper Limit of Crop Yield".[26] His main conclusion was that the upper limit "is already being approached today in those regions with the highest level of agricultural practice—in parts of Japan, of Western Europe, and of the United States." In the following decade from 1963 to 1972 the growth in U.S. crop yields slowed to only 2 percent per yearand in the 3-year period from 1976 to 1975 there was no improvement in crop production per acre.

Agriculture is one area where the nature of technological progress is well understood. Yields can be increased by making plants and animals disease resistant, by reducing pests, moisture, and nutrient constraints and through mutations, proper care, and selective breeding. None of these techniques are open ended. After natural constraints have been eliminated and the genetic characteristics of plants and animals altered to take advantage of a more favorable environment, progress can be painfully slow.

The new hybrid wheats which are now being planted in the Great Plains are capable of yielding 60 to 65 percent more grain than nonhybrids. After this significant innovation is widely diffused, however, there won't be any major cereal or feed grain crops remaining to be hybridized.

The most disturbing aspect to yield technology is not the logic of an upper limit but the fact that once high yields are attained, it may be rather difficult to preserve them. Consumption of DDT has trended downward for more than a decade, partly as a result of Rachel Carson's book "Silent Spring," but also as a result of greater resistance on the part of some insects.

In 1970 drought and an extension of the Southern leaf blight, a fungus disease which has existed in some Southern States for quite some time, reduced corn yields in some parts of the Northern corn belt by more than 65 percent. An even more important longrun concern is the price of fertilizer.

Between 1940 and 1974 there was a tenfold rise in the amount of fertilizer and other agricultural chemicals used in the United States. In 1975 the amount of fertilizer consumed in this country actually declined. One of the main reasons is higher prices for natural gas—one of the principal inputs in the production of nitrogen-based fertilizer products. If the price of natural gas continues to rise at a rapid rate that could have a deleterious feedback effect on the growth of crop yields not only in the United States but the rest of the world as well.

Part III. The Promotion of Increased Productivity

One reason for being concerned about the recent productivity slump is that it seems to be linked to other problems such as inflation. A number of studies have shown that there is a statistically significant inverse relationship between changes in labor productivity and changes in various price indexes that are used to measure inflation.

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[26] *Science*, July 6, 1962, pp. 11-15.

The rather severe slump in the growth of output per employed hour from 3.6 percent in 1966 to rates of 2.0, 2.7, 0.1, and 1.1 percent for the years 1967 through 1970—more than any other single factor—was probably responsible for the accelerated rate of increase in prices and wages which eventually forced President Nixon to impose a wage-price freeze in August 1971.

There was a 3.7 percent surge in labor productivity in 1971 and another robust increase of 3.2 percent in 1972. These increases helped to reduce the rate of inflation in the Consumer Price Index from 5.5 percent in 1970 to only 3.4 percent in 1972. Output per hour only increased 2.2 percent in 1973 and then declined by 2.5 percent in 1974—the largest decline since the end of World War II. While a worldwide food shortage, a quadrupling of the price of imported oil and the end of wage and price controls in April 1974 also contributed to the upward surge in consumer prices to double-digit levels, there is not much doubt that the second productivity slump in less than a decade seriously aggravated the problem of controlling wage and price inflation.

A number of studies have also shown that changes in labor productivity are highly correlated with fluctuations in the aggregate economy.[27] In the period from 1948–63 about half of the year-to-year variation in the annual percentage change in output per man-hour in the private domestic economy can be explained on the basis of associated percentage changes in total real output.[28] There has been a downward shift in the relative amount of productivity received for a given percentage increase in total output since 1963 but that does not appear to have altered the high degree of positive association between these two variables.

Efforts to establish a firm statistical linkage between changes in aggregate productivity and the multitude of underlying variables which are commonly believed to be at least partially responsible for productivity changes, however, have not been very successful. Most of the underlying variables which are presumed to promote productivity advance are trends in nature and so highly intercorrelated with each other as to preclude a firm delineation of their net individual effectiveness.

The larger the industry and the more rapid the growth rate for total output, however, the more profitable it will be to engage in research and development and invest in new plant and equipment containing the most recent advances in modern technology. From an economic point of view, therefore, it is not unreasonable to suppose that there should be a strong positive link between changes in output and changes in productivity. The statistical evidence in support of such a linkage and the large amount of unemployed human and capital resources which are not available in this country suggest, therefore, that the best way to promote improvements in productivity at the present time is to adopt those policies which are likely to be most effective at stimulating an economic recovery.

As one moves from macroeconomic policy to more specific measures for promoting improvements in productivity there is even less agree-

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[27] Frank Brechling, "The Relationship Between Output and Employment in British Manufacturing Industries," *The Review of Economic Studies*, 1965, pp. 187–216; T. A. Wilson and O. Eckstein, "Short-Run Productivity Behavior in U.S. Manufacturing," *The Review of Economics and Statistics*, February 1964; and E. Kuh, "Cyclical and Secular Labor Productivity in U.S. Manufacturing," *ibid.*, February 1965.

[28] Edward Renshaw, "Why Economic Uptrend May Be Short Lived," *The Commercial and Financial Chronicle*, Dec. 3, 1970, pp. 1 and 10.

ment as to what the Federal Government should do to increase productivity. In an article on the meaning of productivity which was prepared for the National Commission on Productivity, Herbert Stein has noted that the striving for higher productivity should not be viewed as a whipcracking exhortation to "work harder" in order to raise some arbitrary abstract measure of economic performance.

> Increasing productivity is a way of increasing the ability of people to do what they want to do. It can provide the wherewithal for achieving a higher standard of living for families now living at the low end of the income scale. It can provide for a choice of leisure—not idleness—in the form of more holidays and vacations and entrance to an earlier retirement from the world of work, and it can provide the resources for improving the physical quality of the enviroment.[29]

Most economists, I believe, would be inclined to agree with this assessment and would also support the National Commission on Productivity and Work Quality's efforts to improve productivity in both the private and public sectors of our economy. The work of the Commission, it seems to me, is likely to be particularly valuable in those instances where improvements will require new legislation, changes in governmental regulations, more cooperation on the part of Government and industry, a greater standardization of products and components within an industry, more collaboration between different industries, or major sacrifices in the part of some firms, management or labor.

There is a sense, however, in which the promotion of productivity can be considered too important to be left to one small commission. Congress and the executive, I believe, must also become more concerned with the impact of national legislation and Federal programs on productivity. It seems clear that there are too many small grant programs in existence at the present time as well as some governmental agencies which have probably outlived their usefulness to society. Our Federal tax system is not only inefficient but also inequitable and far too complicated. Many industries, such as the transportation sector of our economy, are overregulated.[30]

The ACIR, for example, has recently recommended that Congress consider legislation to consolidate the various national transportation regulatory bodies into one intermodal agency.

Such an agency should deal with a much broader range of transportation-related issues than regulatory agencies have to date. Such issues should include modal productivity and efficiency, as well as economy, energy conservation, desired community development, and environmental protection, enhanced mobility, and improved access.[31]

While there is evidence to suggest that public officials at all levels of government are becoming more conscious of the need for additional productivity, it would be my guess that many of the great political controversies of the next decade will continue to center around instances of too much productivity rather than too little output per man-hour. Some examples might be worth mentioning.

Productivity in the municipal bond underwriting profession, for instance, has been so high in recent years as to not provide investors with adequate protection against funny budgeting, hidden operating

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[29] National Commission on Productivity, "The Meaning and Measurement of Productivity," September 1971, p. 3.

[30] Armand Thieblot, "Regulatory Stupidities, Paperwork Bug Firms U.S. Seeks To Assist," *Money Manager*, Jan. 5, 1976, pp. 8 and 33.

[31] ACIR, "A New Approach to Coordinated Transportation," *Intergovernmental Perspectives*, Fall 1975, p. 7.

deficits, and a rather serious problem of unfunded pension liabilities for State and municipal workers.

Output per man-hour in the railway industry and in some of our central city rental housing markets has been kept high in some cases, as a result of too little maintenance. Labor productivity in the bituminous coal industry has also been excessive because of an inability on the part of Congress and the administration to agree on a strip mine reclamation bill.

In the electric utility industry output per man-hour has been increased tremendously by concentrating generating capacity in large central powerplants. With the price of imported fuel oil now more than four times as great as it was at the beginning of 1973, however, there are probably many instances where it would be more advantageous for the economy as a whole to have some of this generating capacity located at utilization points so that industry and large commercial establishments can make better use of waste heat even if it means lower labor productivity in the electrical generating industry.

Studies have shown that there are twice as many surgeons in proportion to population in this country as compared to England and Wales and that American surgeons perform twice as many operations. Many of these extra operations appear to be unnecessary. There is also evidence to suggest that physicians are prescribing an enormous quantity of drugs that are unnecessary or even harmful. More than half of all general practitioners seldom, if ever, participate in medical updating programs, which may be one reason for the steep rise in malpractice suits. These are all sensitive areas where the appropriate answer to an important problem may be less productivity rather than more.

In our efforts to develop a social security system that is almost entirely financed by employee and employer contributions we have inadvertently created an environment which discourages employers from hiring older workers, students, and part-time and disadvantaged persons whose productivity is suspect of being below average. This is clearly an area where new policies and financial arrangements are called for even if it means some sacrifice in the growth of labor productivity. In the remainder of this manuscript. I will suggest a possible solution to this problem and also consider some other cases where new policies may be desirable.

Research and Development

While our knowledge about the relationship between R. & D. and productivity is somewhat limited, most of the available evidence suggests that R. & D. has been an important contributor to economic progress. The research that has been undertaken to establish a relationship between R. & D. and productivity at the level of the firm, the industry and the economy as a whole is not inconsistent with the hypothesis that its contribution has been positive, significant, and high, on the average.[32]

The role of the Federal Government in promoting research and development, moreover, appears to have been fairly rational.[33] There

[32] National Science Foundation, "A Review of the Relationship Between Research and Development and Economic Growth/Productivity," Office of Economic and Manpower Studies, February 1971, 76 pp.
[33] Edward F. Renshaw and Vernon Renshaw, "Some Notes on the Rationality Model," *The Southern Economic Journal*, January 1970, pp. 244-51.

has been a great deal of support for basic science as well as the mission-oriented research that was necessary to achieve such objectives as a strong national defense. In such vital areas as health and agriculture there has not only been generous support for new research but a not inconsiderable expenditure of resources on behalf of a wider diffusion of the new technology for increasing crop and livestock yields and improving public health.

In the case of atomic energy, where the developmental risks were sizable and where it appeared that the civilian benefits might prove to be of enormous value to society, the Federal Government has moved vigorously to create a whole new industry. Other industries such as the commercial aircraft, drug, seed, computer, electronic and scientific instruments industries have also benefited fairly directly from the Government's sizable investment in research and development.

While the Federal Government might be criticized for having been rather slow to respond to new needs and objectives and for having overemphasized some technologies such as the liquid metal fast breeder reactor, there is considerable evidence to suggest that our Federal R. & D. programs do get reoriented and can be expected to respond in a creative way to new challenges and opportunities once they are clearly perceived as being in the national interest.

Private R. & D. on the other hand, tends to be shortsighted and may not move as far and as fast in the direction of energy-conserving innovations as it should without greater involvement on the part of the Federal Government.

Zvi Griliches, one of the leading authorities on technological changes and its affect on the economy, has suggested that most economists, if queried, would assert that there is underinvestment in research by private firms because much of its product is not appropriable by the private firm. In the past when the social returns from R. & D. were very high, on the average, and when an important new innovation might have been expected to not only save labor but capital and energy as well, this inability to capture all of the benefits from a new innovation may not have mattered too much. For the large amount of spillover benefits could be expected to generate a very sizable demand for new products and insure enough monopoly profits from being first to introduce an important new innovation to amply reward the innovator even if the innovation was not patentable.

The opportunities for improving the efficiency of energy converting devices are known to be quite limited, however. As we approach these limits it will generally not be possible to save energy without a sacrifice of some other kind of productivity such as a decline in output per unit of capital. This will tend to increase the cost of energy converters, force producers to raise their prices and in so doing restrict the market for the new innovations. While the social benefits may be sufficient to justify further efforts in behalf of energy conservation it is by no means clear that the capturable private benefits will be sufficiently great to motivate an optimum amount of innovation and insure that more efficient energy converters are purchased and widely utilized.

The problem of insuring an optimum amount of energy conservation is likely to be further exacerbated in the next decade or so by a continuation of some price controls on domestically produced oil and natural gas. When energy, or any other item, is priced at less than its

marginal cost there will not only be underinvestment in resources that can be used to conserve energy but a tendency to use fossil fuels for purposes that do not provide human satisfaction equal to their real cost to society.

In a world where inflation and equity consideration make it difficult, if not politically impossible to allow the price of domestically produced energy to rise to equal the cost of imported energy, an economic case can be made for the imposition of minimum Federal insulation and performance standards for all new buildings, automobiles, appliances, and other energy converting devices.

The energy bill which was enacted into law in December 1975 does provide for the establishment of efficiency standards for major household appliances and new automobiles beginning with the 1978 model year. This is a step in the right direction. More progress needs to be made, however, in establishing adequate standards for the insulation of new homes, factories, and commercial establishments.

Regulatory Reforms

A report prepared for the Productivity Commission and the Council of Economic Advisers by a special Task Force on Railroad Productivity in 1973 estimated that waste in the form of inefficient and idle transportation resources of all kinds were costing shippers and consumers in the range of from $4 to $10 billion per year. Efforts are now being made to eliminate some of this waste through increased use of containerization and intermodalism, improved labor relations and work rule revisions, regulatory modernization, dedicated trains that significantly improve the speed and reliability of transporting perishables, and through the establishment of a rail car clearinghouse. [34]

Another study sponsored by the Productivity Commission has found that the fruit and vegetable industry in the United States uses 2,400 different sizes of containers for packaging and shipping its products compared to Switzerland, where only four different sizes are in use. A modular system using standard containers and pallets could be expected to improve productivity through less wasted space in trucks, trains, warehouses, and stores, less damage to food products in shipment and less wasted labor at all points. If the food industry does not act to standardize its containers, Congress should be prepared to establish a special regulatory body for the purpose of imposing a more rational set of standards on the container industry.

The need for a more rational approach to containerization is even more apparent in the beverage industry where some States have unilaterally moved to either ban or tax some containers out of existence. The so-called nonreturnable bottles do have an advantage over returnables in that they are lighter and less costly to produce. If they were labeled reusable and standardized with respect to size, shape, and color, with industrywide redemption centers being established in most towns for those bottles that are returned in reusable condition, it might then be possible to save energy and materials and also retain most of the productivity benefits which have been achieved as a result of a more centralized system of large scale bottling and processing plants. The malt liquor, bottled and canned soft drink industries were among the few industries with an accelerated rate of growth in

[34] *Fourth Annual Report* of the National Commission on Productivity and Work Quality, pp. 27-29.

output per man-hour from 1966–72 compared to earlier periods. The gain in labor productivity in these industries has averaged more than 6 percent in recent years, and would surely be reversed if we went back to the old fashioned returnable bottles system.

Electric power is another industry where regulatory reforms might help to improve economic efficiency. In the past few years there has been a revival of interest in the theory of marginal cost pricing applied to electrical utilities and variously referred to as time-of-day, peak responsibility, or peak load pricing. After extended testimony by economists and environmental groups, the Wisconsin Public Service Commission in August 1974, ordered a nearly uniform residential electric rate structure for the Madison Gas & Electric Co. during the summer months and announced that marginal production cost information would hence forth provide the basis for electric tariff design. In New York and California generic hearings are now underway to assess the benefits and costs of implementing new rate schedules that embody some of the principles of marginal cost pricing.

The need for reforms is readily apparent in operating statistics. Between 1967 and 1973 the load factor of the electric utility industry declined by more than 5 percent with no increase in the margin of reserve capacity that is available to satisfy noncoincident peak load demand. One way to increase the efficiency of this industry and also improve the rationing of electric power during periods of crisis when fuel and/or generating capacity is insufficient to satisfy total demand would be to give all consumers the privilege of paying a separate price for energy consumed and the maximum amount of electric power that they would like to be able to utilize during periods of peak, system wide demand.[35] Persons that shift a large portion of their electrical load to off-peak hours would then be rewarded by not having to contract for as much peaking capacity.

Another way that it might be possible to improve the load factor of the electric utility industry would be to move in the direction of greater interconnection. In the 1964 National Power Survey it was estimated that increased interconnection and coordination might yield net savings in investment expenditures amounting to several billions of dollars by 1980. While the sharp rise in the price of fossil fuels may have reduced the potential benefits somewhat, it would seem appropriate for Congress to seriously examine the costs and benefits that might be associated with moving in the direction of a national power grid.[36]

Mass Transit Subsidies

Federal subsidies for new capital equipment have increased labor productivity in both the new equipment and mass transit industries but have been criticized by the Brookings Institution and others as being wasteful and inefficient:

> If the Federal Government is paying two-thirds of the cost of new equipment, but nothing toward repair and maintenance, local transit officials will naturally replace buses very quickly, long before they should be scrapped. The total cost of providing mass transit will rise sharply, and a large part of the subsidy will serve not to benefit riders but to cover the costs of inefficient decisions.[37]

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[35] This proposal is discussed more fully in "The Pricing of Electricity: A Suggestion," *Public Utilities Fortnightly*, Jan. 1, 1976, 28–32.

[36] Edward Cowan, "National Power Grid Debated, *New York Times*, March 30, 1975, p. 11F.

[37] Charles L. Schultze and others, *Setting National Priorities: The 1974 Budget*. The Brookings Institution, 1973, p. 244.

Transit subsidies of a more general character can be justified on the grounds that they will help to conserve gasoline, can be expected to reduce air pollution, will lessen traffic congestion [38] and also because operating subsidies may be necessary in some instances to preserve large amounts of consumer surplus which might otherwise be lost if existing transit systems went out of business.[39]

In November 1974 Congress passed an $11.8 billion transit bill which authorizes almost $4 billion that may be used for operating subsidies over a 6-year period. This is a step in the right direction but probably does not go far enough. The Advisory Commission on Intergovernmental Relations has recently recommended that Congress pass legislation to merge funds for the urban system, secondary highway system and mass transportation programs into a single block grant which could be used for any mode and for both capital and operating purposes without restrictions.

The Financing of Social Security

The present system of financing social security is biased against work sharing in periods of widespread unemployment. It also discourages employers from hiring disadvantaged workers, students, part time, elderly and other low income wage earners. These biases are related to the fact that wage and salary payments above a threshold amount are exempt from social security taxes. Profits will be maximized, other things equal, if employers retain workers with higher absolute productivity who have already earned the threshold amount rather than hire new employees and less skilled workers that have not yet made a maximum contribution to social security.

One way to encourage employers to both hire and retain more disadvantaged workers would be to simply exempt the first $3,000 or $4,000 of a worker's income from all social security taxes and make up the loss in tax revenue by requiring workers and employers to contribute a fixed proportion of all additional wage and salary payments to the social security fund. These reforms would also have the advantage of making our social security system less regressive.

Water Pollution Control Subsidies

The Federal Water Pollution Control Act Amendments of 1972 has set water quality standards for waste treatment facilities and has authorized Federal grants equal to 75 percent of the cost of eligible projects. This cost sharing arrangement is so generous as to be wasteful of capital resources. A federally sponsored study has indicated that some communities, in an apparent zeal to obtain Federal subsidies, are building sewerage facilities large enough to handle expected population growth for as much as the next 2,000 years. In less extreme instances communities have been installing up to twice as much sewerage capacity per household as is needed.[40]

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[38] Edward F. Renshaw, "A Note on Mass Transit Subsidies," "National Tax Journal," December 1973, pp. 639–44.

[39] Edward F. Renshaw, "The Survival Benefits Associated with Mass Transit Systems: A Justification for Operating Subsidies," "Traffic Quarterly," April 1974.

[40] Gladwin Hill, "E.P.A. Is Curbing Sewer Main Subsidies," New York Times, Oct. 15, 1974, p. 1.

The high subsidy rate has a further disadvantage since it encourages suburban sprawl. A study which was prepared for the Federal Government by the Real Estate Research Corporation of Chicago in 1974 has shown that planned urban fringe and suburban development can save communities up to 50 percent in land costs, construction costs, energy consumption, air and water pollution and municipal operating costs, as compared with haphazard growth.

The Environmental Protection Agency has announced that it plans to pay more attention to land use patterns in the future when awarding Federal grants for sewers, so as to reduce urban sprawl and insure a more efficient use of public resources. This may tend to reduce the need for capital grants but will also impede construction activity and add to the Federal bureaucracy. An alternative approach would be to lower the percentage of total costs to be shared by the Federal Government so as to make it increasingly clear to land developers and suburban planners that there is no such thing as free lunch.

Another factor which encourages over expansion of public facilities relative to private investment is the exemption of the interest income on municipal bonds from the Federal income tax under section 103(a)(1) of the first income tax amendment. From 1920 to 1943 there were 114 resolutions introduced into the U.S. Congress to repeal the exemption feature. Despite concerted opposition from public finance experts, however, Congress has some six times defeated proposals to remove the exemption and on many more occasions such proposals have never reached a vote.

The more recent strategy has been to try to enact new legislation which would provide State and local governments with a direct interest subsidy if they elect to issue taxable bonds. While it may be desirable from a political point of view to provide State and local governments with an alternative subsidy, it seems clear that the subsidy should not be a fixed proportion of annual interest payments.

A preferable approach, from the point of view of economic efficiency, would be to link the amount of subsidy, not to the quantity of funds actually borrowed, but to some overall indicator of borrowing capacity, financial need, or some other objective standard which seems fair and reasonable. My own suggestion would be to tie the subsidy to a State's personal income and use the proceeds to provide property tax relife on a per capita basis within each State, if the State and its political subdivisions agree not to issue nay more tax-exampt bonds. An alternate subsidy linked to property tax reduction would not only help to eliminate a glaring loophole in our Federal tax system but would also have the advantage of encouraging State and local governments to be less wasteful in the use of capital resources.

Part IV. Some Concluding Remarks

The average after tax spendable weekly earnings of production workers in 1967 dollars increased almost 45 percent from 1947–72 and then declined by almost 10 percent form 1972–74 to a figure that was actually somewhat less than the real after tax earnings of production workers in 1965. What the average American voter seems to be saying in connection with the defeat of major bond issues and their

enthusiastic endorsement of proposals for tax and expenditure cuts is that government, at all levels, should be more economy minded and less profligate in the use of scarce resources.

While I do not believe that the United States and the more industrialized nations of the world can avoid a fairly rapid and inevitable decline in the future rate of productivity advance, it does seem to me that there may be a large number of ways in which resource productivity, including the resources which utilized or developed by government, can be improved in at least a modest sort of way. Productivity, in the final analysis however, is a complex subject. Our knowledge with regard to the effective promotion of productivity advance is rather meager. Since future advances in productivity will depend to an increasing extent on the substitution of one or more inputs for another, it seems clear that all strategies and proposals for promoting improvements in productivity must be carefully analyzed on a case by case basis, not only in terms of economic efficiency but also in terms of probable effect on the distribution of economic well being.

In the past when productivity was advancing at a rapid rate politicians could very often afford to ignore large and persistant differences in the distribution of income and wealth. In the future, the quest for greater equity may very well turn out to be of greater relative importance than the promotion of economic growth.

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